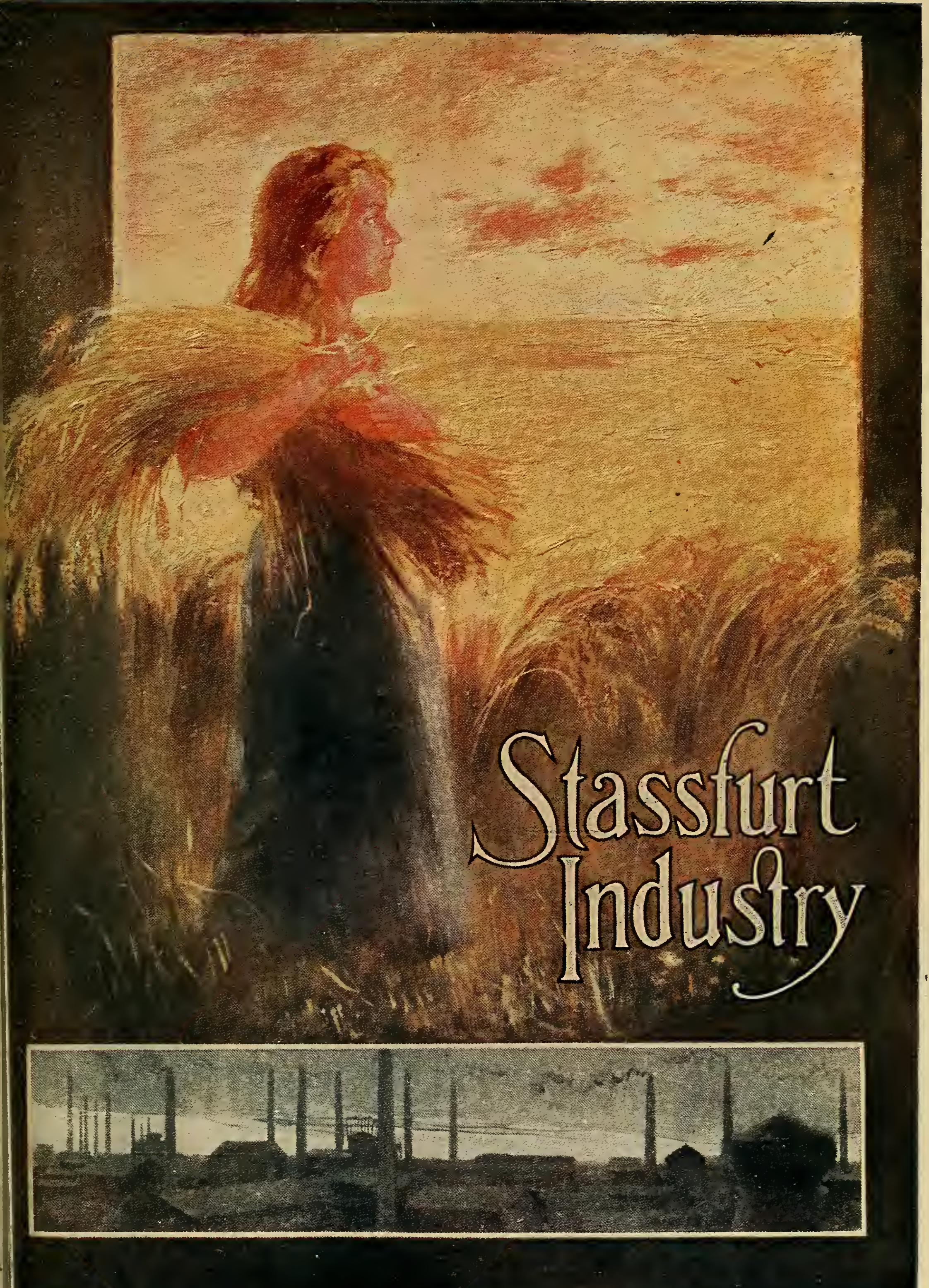
Stassfurt
Industry

THE
STASSFURT INDUSTRY

Published By

GERMAN KALI WORKS,

NEW YORK, N. Y.
93 Nassau Street.

ATLANTA, GA.
1224 Candler Building.

CHICAGO, ILL.
562 Monadnock Block.

NOTICE.

Every farmer can obtain, free of charge, a copy of the following agricultural books:

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FARMERS' NOTE BOOK,
COTTON CULTURE,
TOBACCO CULTURE,
ORANGE CULTURE,
STRAWBERRY CULTURE,
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PREFACE.

THOUSANDS of American farmers use potash, Hundreds of thousands of them *should* use it, both for their own present and future profit and to prevent their posterity from receiving a heritage of ''worn out'' soils. But ashes—once the most common sourch of potash—are no longer to be had in quantity. Our forests are now cleared and the ash heap of the pioneer is a thing of the past, while wood as a fuel for factories and railroads has been replaced by coal and oil. Where, then, shall we turn?

Man seldom feels a pressing and continuous need which Nature does not meet—and such has been the case with potash. Whithin the fifty years which measure alike a rapidly increasing demand for it and thc practical disappearance of the old source of supply, there has been found, in one of Nature's storehouses, an inexhaustible accumulation of potash. To the discovery of the deposit the term fortunate can be applied, since it came in time to meet need; but the storing of the potash, when one considers the importance of this element, for the welfare of our

fields and its necessity in maintaining the food supply for the rapidly increasing mouths of the world, the storing we must call Providential. The process of Nature, by which this accumulation was made possible, are marvellous, and the methods which man has devised to utilize the store and convert it into forms best suited to the diverse requirements of his fellows are ingenious. The many inquries which arise concerning potash in its varied forms, prove that its users are interested in its history; therefore, this little sketch has been prepared to meet the friendly wishes of those who already appreciate potash. The story is interesting and those who read it will derive pleasure and profit.

HISTORICAL SKETCH.

STASSFURT, near the Harz mountains in northern Germany, has been, for many centuries, noted for its salt works. There, in the early days of history, common salt was obtained by evaporating the water from its salt springs, and later, from its wells. When mines of rock salt were discovered in other places, the evaporation process was abandoned partly because the brine from the springs and wells, generally contained, beside table salt, the salts of potash and magnesia. Adout fifty years ago, the Prussian Government which owned the mines, began boring for rock salt, and in 1857 found it in immense quantities at Stassfurt, 1,080 feet below the surface. Immediately above this rock salt are deposits of various potash and magnesia minerals, at first considered of little value and actually thrown away as worthless, but later to supply the world with potash. The agricultural value of potash became generally known in 1860, through the researches of that eminent scientist, Prof. Justus von Liebig, and in 1861 the first factory for refining crude potash minerals was established at Stassfurt. Stimulated by the success attained in the use of potash as a fertilizer, the industry of mining and manufacturing its salts has grown to enormous proportions; new deposits have been discovered and mines opened, until to-day there are about 45 large mining establishments in active operations.

ORIGIN OF THE STASSFURT SALT AND POTASH DEPOSITS.

The Stassfurt salt and potash beds were formed (or deposited) in ancient, geologic times. Long before history began, these minerals were laid in place by the evaporation of sea water confined in lakes, which, somewhat like the Dead Sea and Baikal Lakes, were without outlet. These were connected, however, with the ocean by channels, ordinarily dry, but through which the sea water was forced at times by great storms and tides. In this way fresh supplies of salt were received into these lakes, and as the climate of Europe was tropical during this formative period, the surface evaporation of the water was exceedingly rapid. As the water levels of these lakes thus sank, fresh supplies washed in from the sea, holding in solution then, as now, many salts. Evaporation carries off only pure water, so, in course of time, as more salts were entering the lakes and none going out, the water became saturated with salts until those least soluble in water began to separate from the more soluble ones and deposit themselves in more or less uniform strata. By such continued evaporation and ever increasing concentration, immense layers of rock salt and anhydrite (sulphate of lime) were formed.

As the rock salt separated and the concentration became greater, other more soluble salts began to deposit and cover

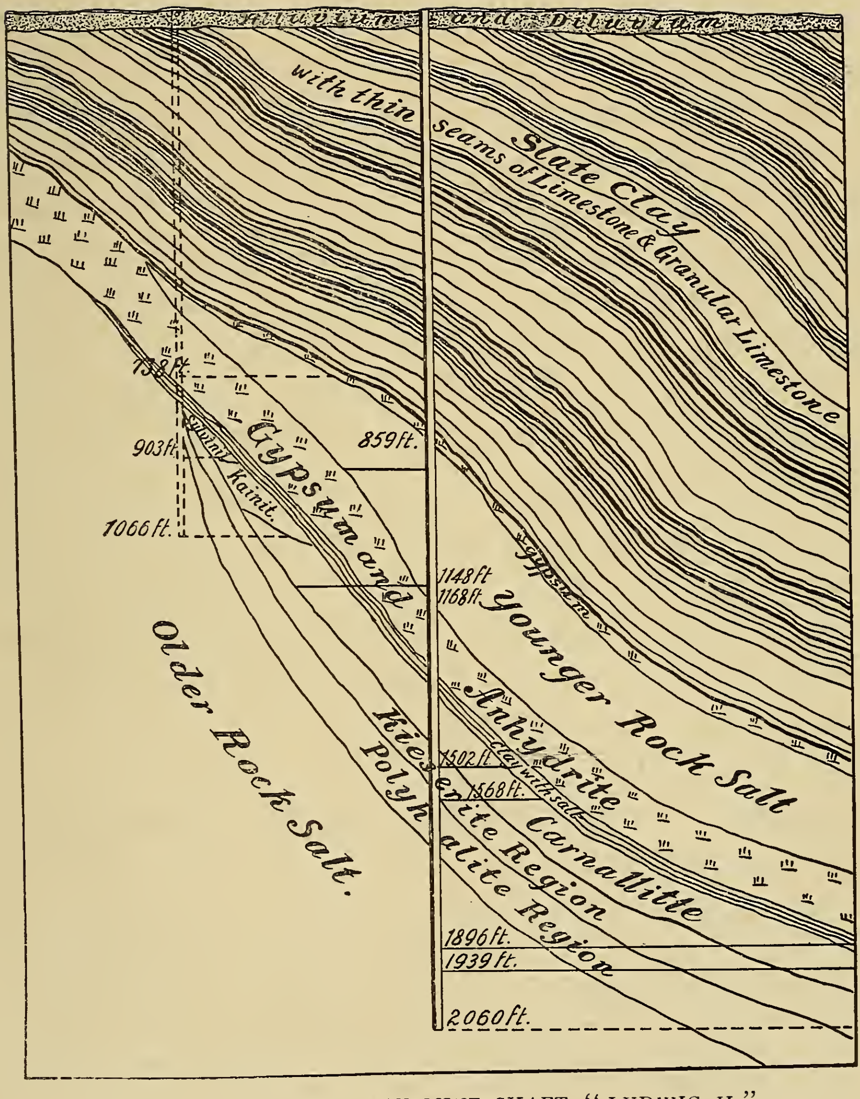
it, layer upon layer, up through the mineral polyhalite, which is composed of sulphate of lime, potash and magnesia, —kieserit, which is sulphate of magnesia,—and the "potash region," the stratum of carnallit, a compound of chlorides of potassium and magnesium. This last named stratum ranges from 50 to 130 feet in thickness, and supplies the crude salts from which the most important and concentrated potash salts are refined.

From thus referring to strata it does not follow that these deposits are in smooth, clear-cut layers. From time to time, as additional water came in from the sea, the lake water became so diluted that precipitation was arrested to a certain extent, and, later had to commence again; thus anhydrite is found in the rock salt strata, and seams of rock salt in the polyhalit and other upper layers. Potash and magnesia salts are the most soluble and, therefore, naturally found at the tops of the deposits.

Had these deposits been exposed to the action of rain water they would have been dissolved, but they were protected during geologic changes by a covering of "salt clay," impervious to water. Above this salt clay roof occurs a deposit of anhydrite beneath a second deposit of rock salt,—a later formation and probably of recent origin, geologically speaking. The depth of the Stassfurt salt deposit, from the top of the upper to the bottom of the lowest stratum is some 5,000 feet. The beds underlie the extensive country reaching approximately to Thuringia on the south, to Hanover on the west and to Mecklenburg on the north.

These deposits, in the order of their placing, follow well understood physical and chemical laws; and yet local conditions and geologic disturbances fixed the relative positions of strata and account for more or less apparent disturbances as shown by the diagram. At a few places surface water found access through cracks or fissures, and either carried away the potash salts or changed them into secondary products; from which action in the upper strata occur beds of kainit, sylvinit, hartsalz and other compounds of less importance.

This description, somewhat tedious to unscientific readers, becomes of surpassing interest when the enormous importance of the formation is considered. But for these peculiar conditions at Stassfurt (conditions generally termed accidental) these potash deposits could not have been formed; and vast tracts of agricultural lands, now made fertile and productive by the use of potash from this inexhaustible store, would be sterile and barren for want of it. There is no question as to this scientific fact, and thoughtful readers may well again peruse the story of these wonderful deposits and question whether a formation—all but a creation—of such importance to the human race, can be considered a mere chance,—a simple accident of nature.



SECTION OF POTASH SALT MINE SHAFT "LUDWIG II."

DESCRIPTION OF THE SALTS.

Salt is the chemical name for a compound composed of an *acid* joined to, or combined with, a *base*. For example, burnt lime is a *base*, which, in combination with sulphuric *acid*, forms a *salt* called sulphate of lime; similarly the *base* sodium combined with hydrochloric *acid* forms the *salt* sodium chloride. This last is the compound to which, popularly, the word "salt" is applied, for sodium chloride is our common table salt, but chemically tbe term is a general name for compounds produced as described above. The Stassfurt deposits contain various salts and combinations of salts, many of which contain little or no potash. The following list gives those most important as potash producers, with their mineral names, and chemical formulae;

Carnallit,	$KCl, MgCl_2, 6H_2O$.
Kainit,	$K_2SO_4. MgCl_2, 6H_2O$.
Sylvinit,	$KCl, NaCl, K_2SO_4, MgSO_4, MgCl_2, 6H_2O$.
Hartsalz,	$KCl, NaCl, MgSO_4, H_2O$.

Upwards of thirty different minerals are found in the Stassfurt deposits, of which some twelve contain more or less potash. The four above named yield the main supply of commercial potash, and of these the first three are most important.

Carnallit, which is the chief source of muriate of potash and other concentrated salts, usually occurs mixed with

rock salt and other minerals in layers averaging more than 85 feet in thickness. The color varies, and shades through white, bright to dark red, yellow, and light to dark gray, to a watery hue. In a strong clear light the brilliancy of carnallit crystals and their varied colorings give to its mine galleries a strikingly beautiful effect. Carnallit as mined contains about 9 per cent. of actual potash. In its crude state it is used as a fertilizer only in localities which are not very far from the mines; because from its property of absorbing water, and its bulk as compared with the small percentage of potash which it contains, it is more expensive than the concentrated salts, where cartage or freight has to be considered. The deposit of carnalit is generally intersected by rock salt and often by other minerals, and is so vast in extent as to be practically inexhaustable.

Kainit, a mineral compound of the sulphates of potash and magnesia with magnesium chloride, is not found in the same abundance as carnallit, but nevertheless in such quantities as to meet all probable needs for many generations to come. It occurs in large, irregular deposits, and, as mined, is usually red and more or less mixed with rock salt, of which it contains about 30 per cent. In its crude state it is largely used as a fertilizer, after being crushed and ground, and contains at least 12.4 per cent. actual potash (K_2O). This percentage of potash in kainit is guaranteed, but the materials with which it is mixed or blended differ more or less according to circumstances. Most of the kainit mined is sold in its natural state for

fertilizing purposes, although a considerable part is used in the manufacture of high grade sulphate of potash and other concentrated products.

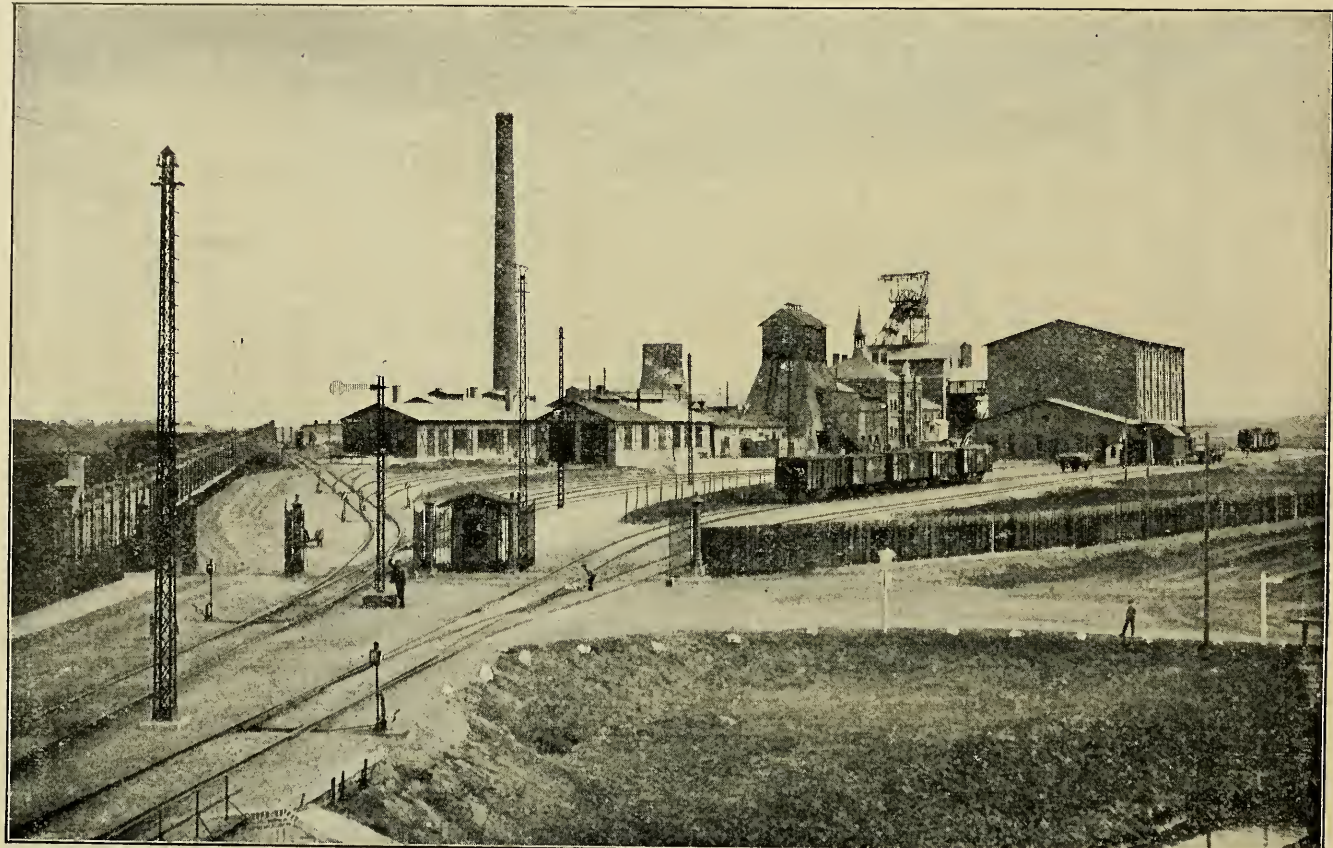
In some mines, especially those more recently opened, instead of kainit is found the so-called *hartsalz* or hardsalt, a mixture of muriate of potash (sylvine), kieserit and rock salt. Hartsalz shows much the same chemical composition as kainit, and though differing from it in chemical structure, is, for most purposes, identical with it.

Sylvinit, although of more recent introduction than either carnallit or kainit, like carnallit is not generally sold in the United States, is in the main, a mixiure of sodium and potassium chloride or rather, of sylvine and rock salt with a little kainit and contains, on an average, 14 to 18 per cent. actual potash in the form of chloride (muriate). It is finely ground for use as a fertilizer, or is manufactured into concentrated potash salts.

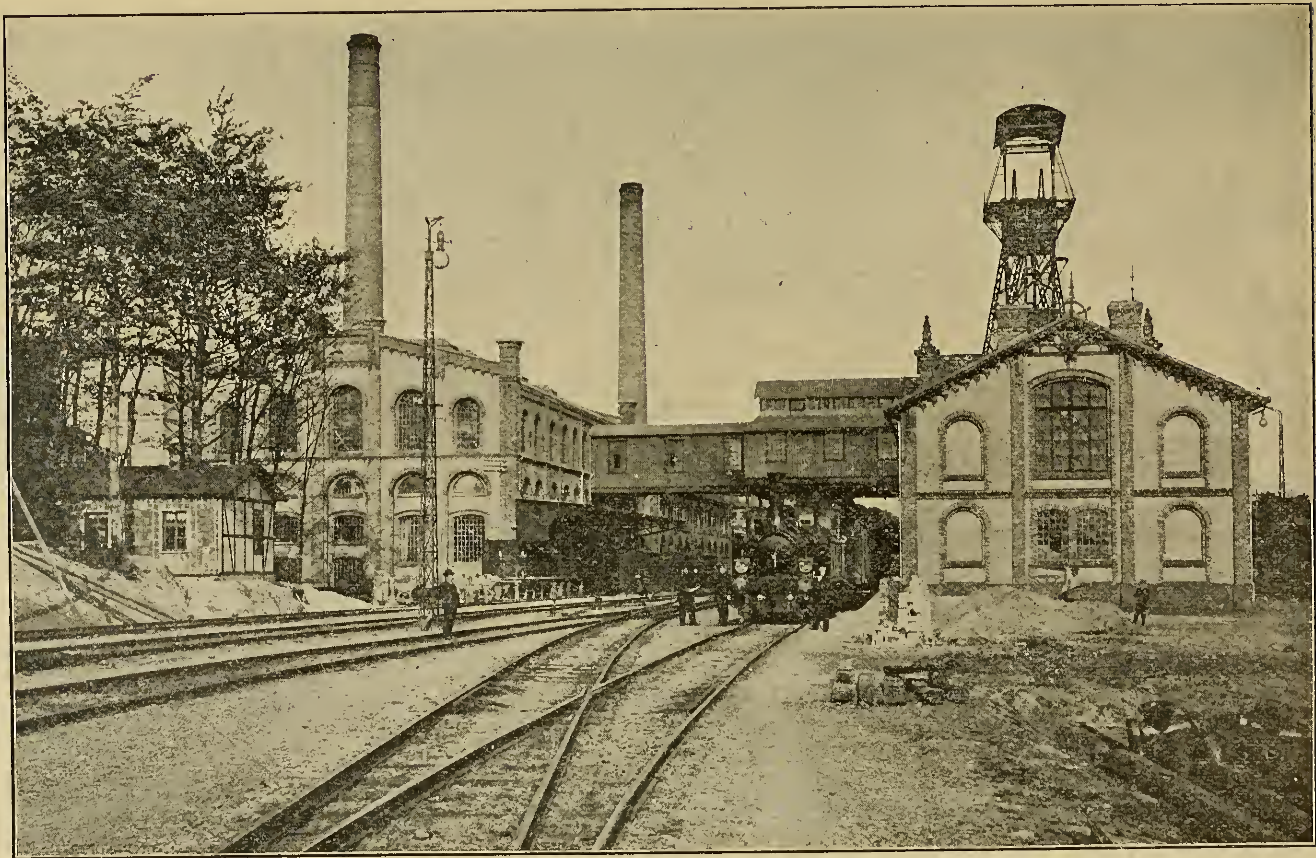
Of these four crude potash salts only kainit and hartsalz are used in the United States; On account of the freight rates the results obtained from the concentrated forms of potash pay better. Kainit is extensively used in the Coast Line States, not only as a fertilizer, but also as a manure preservative, to check attacks of injurious insects, and as a remedy against cotton disease (blight). For such purposes it is cheap and satisfactory and likely to be used in increasing quantities.

MINING THE SALTS.

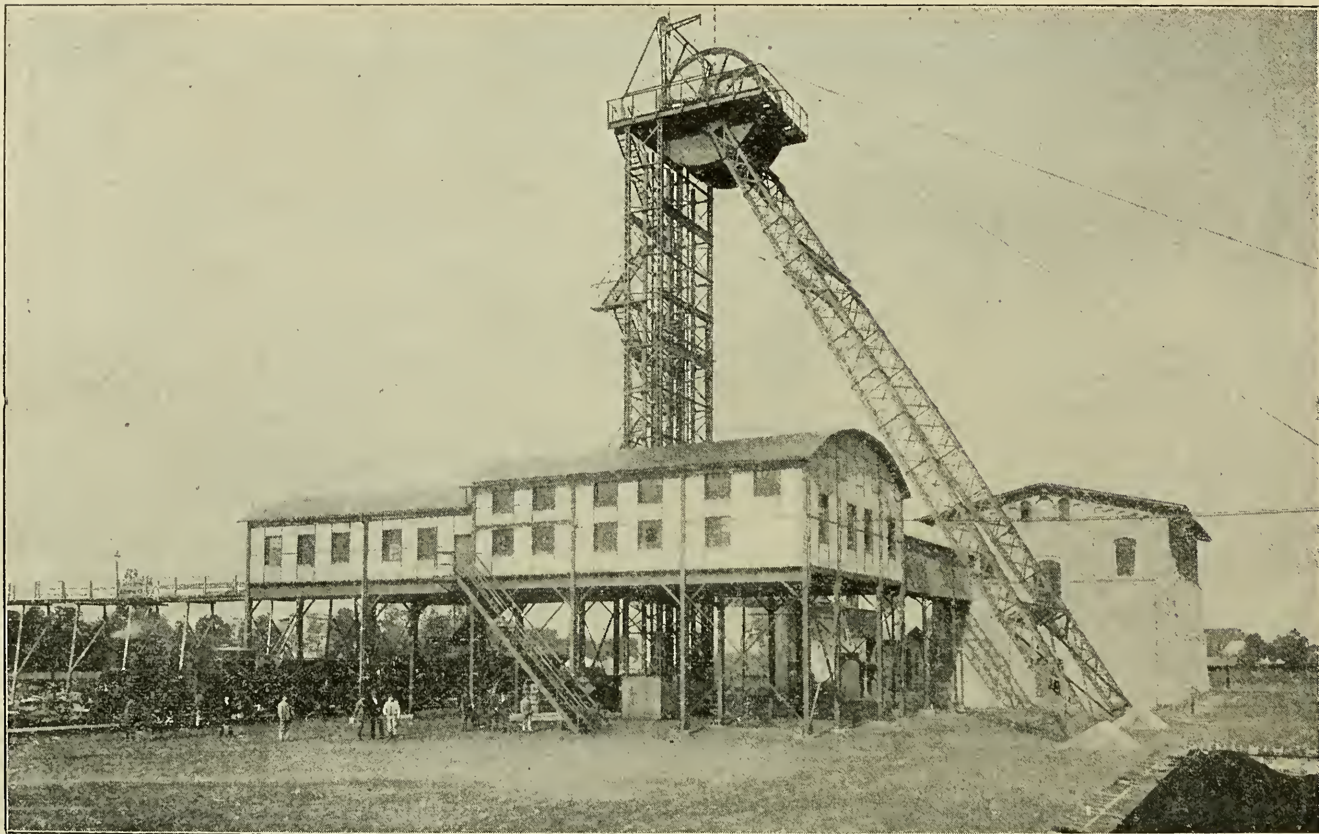
The potash-bearing strata, from 1,200 to 2,500 feet below the earth's surface, are reached by ordinary mine shafts. In sinking these shafts, great care is taken to preserve unbroken the cap materials impervious to water, and thus to prevent the highly soluble potash-bearing salts from being rapidly leached or washed away by the surface waters. This inflow of water is made impossible by sinking iron tubes or lining the shafts with concrete. Water is the great danger in potash mining, and has destroyed valuable mines. Generally potash mines have a reserve or emergency shaft, some distance from the working shaft, protected by strong safety-pillars. Another mining difficulty is the "pillaring" or supporting the mine-roof as its mineral supports are cut away. Formerly pillars of salt were left for this purpose, but they disintegrated so rapidly as to be dangerous, and the safer system was adopted of completely filling up the excavations with the waste salts and rock salt. Within the mines, potash salts are broken down by blasting as in ordinary mining. In many of the works, electricity is used for motor power and in lighting. The mines are necessarly kept perfectly dry, and visitors are free from the inconvenience and discomfort usual to underground workings. The carnallit blastings tear off large blocks which are broken up by the miners and transported in small cars to the shafts, thence to be hoisted to the surface and delivered to the chemical works for grinding and further treatment.



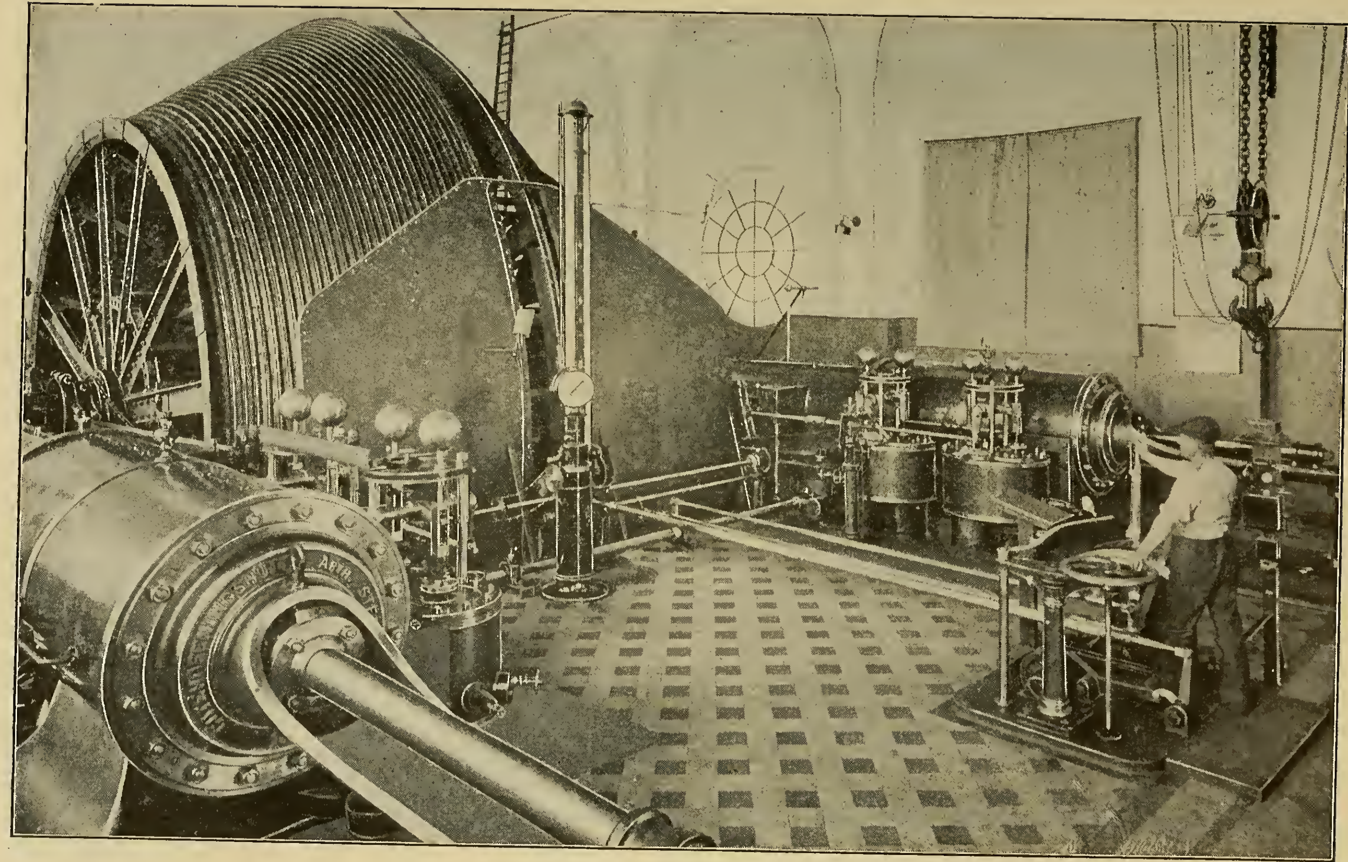
EXTERIOR OF A POTASH MINE.



POTASH MINE WORKS, SHOWING RAILROAD FACILITIES.

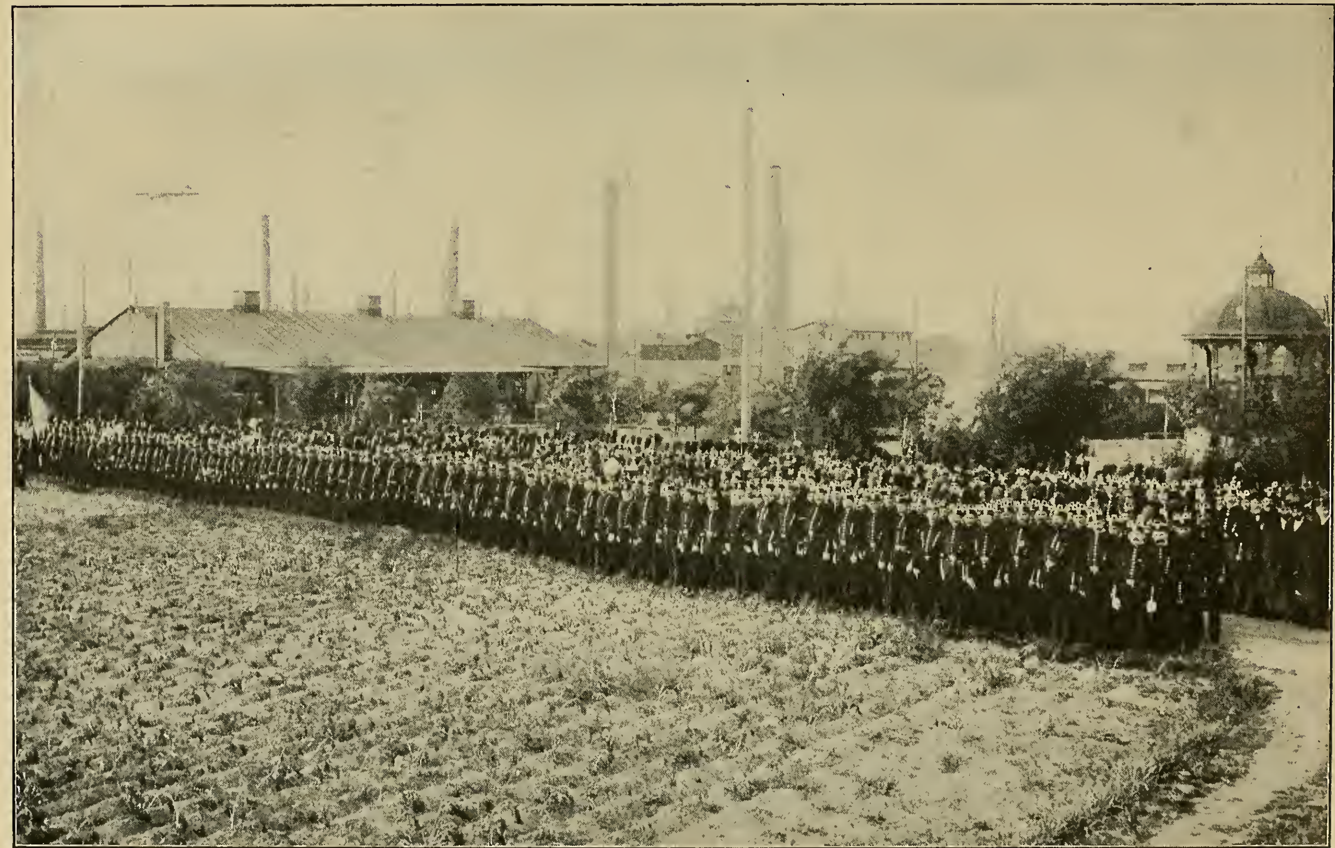


HEAD-GEAR FOR LIFTING PRODUCTS FROM THE MINES.

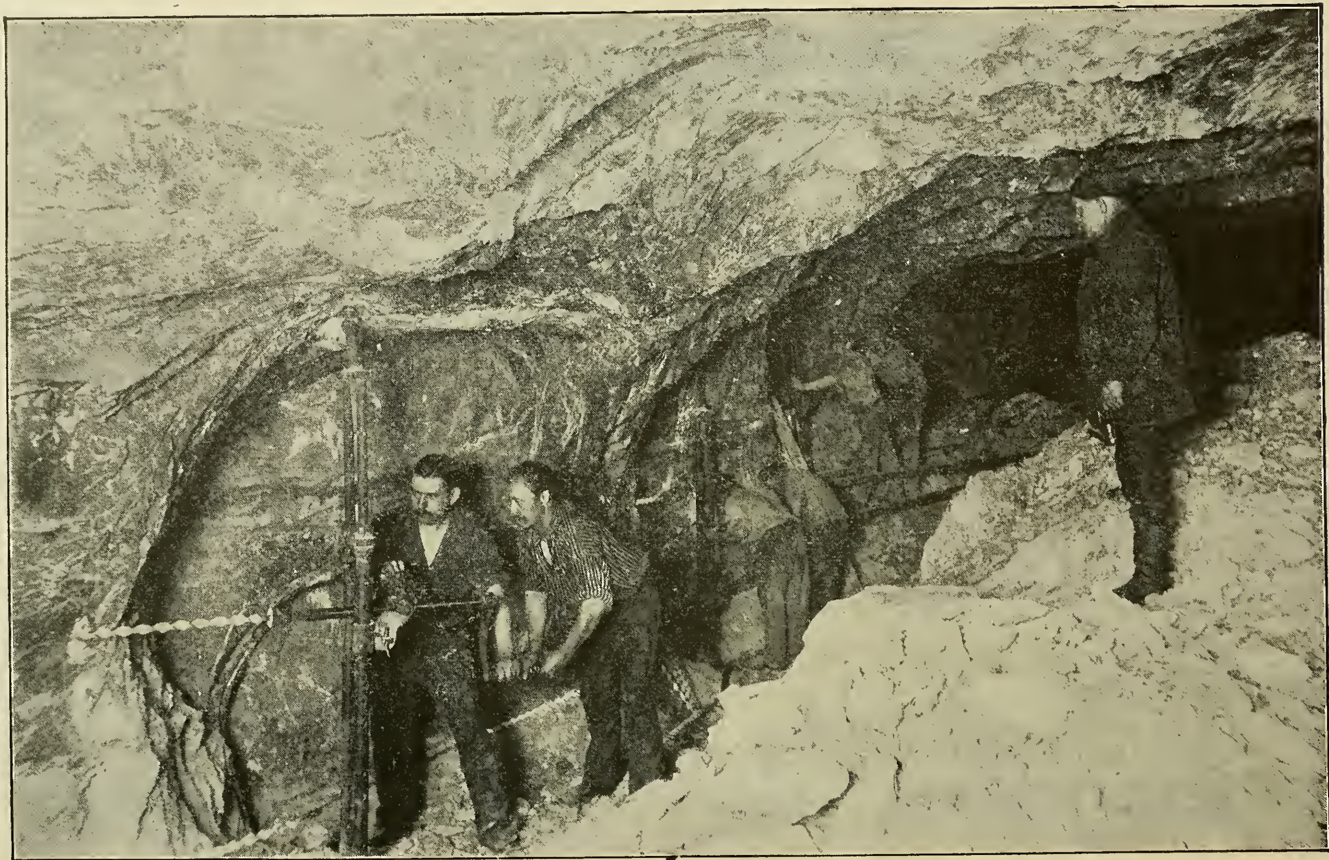


HOISTING-ENGINE.

LOADING POTASH SALTS ON LIGHTERS. RIVER ELBE.



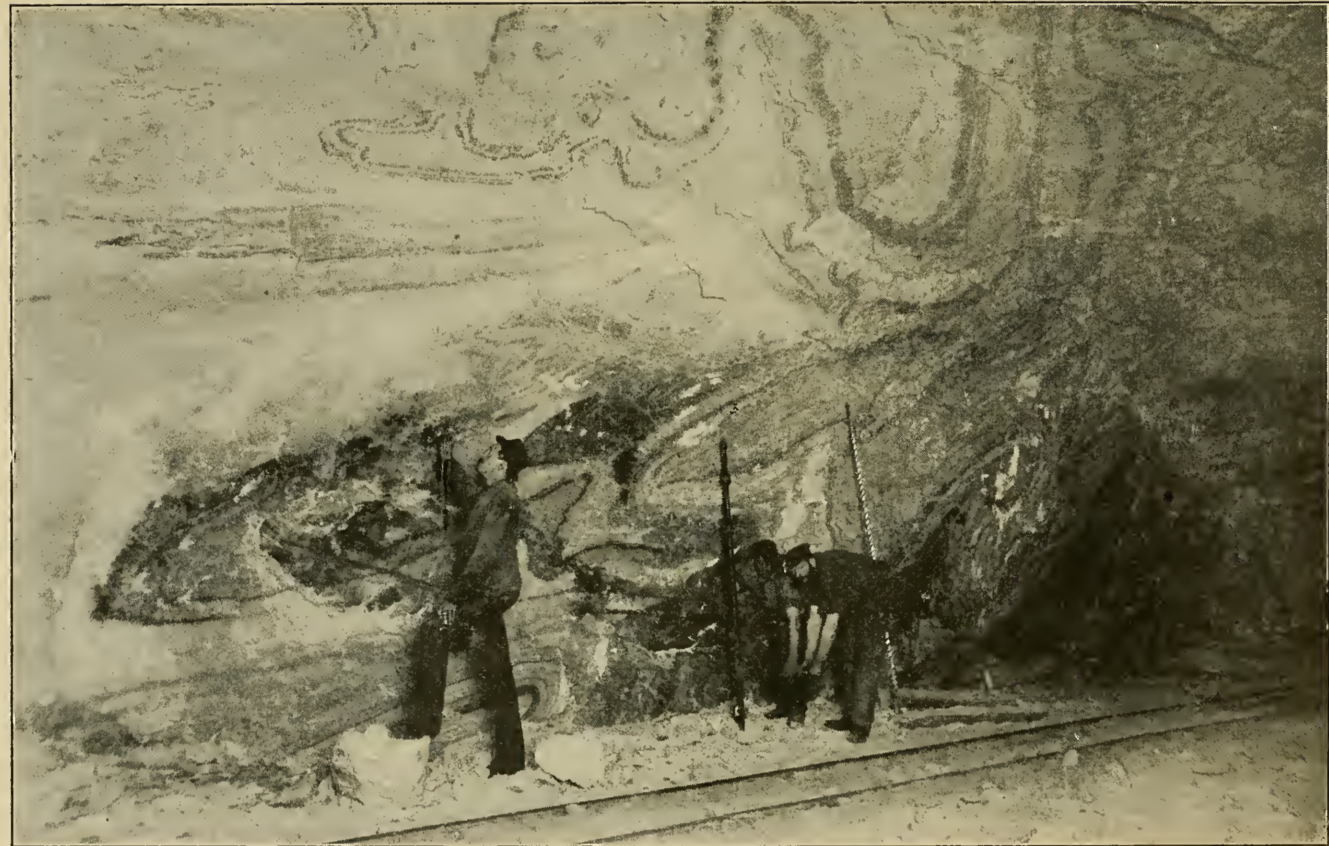
GROUP OF POTASH MINERS.



DRILLING IN POTASH MINE PREPARATORY TO BLASTING.

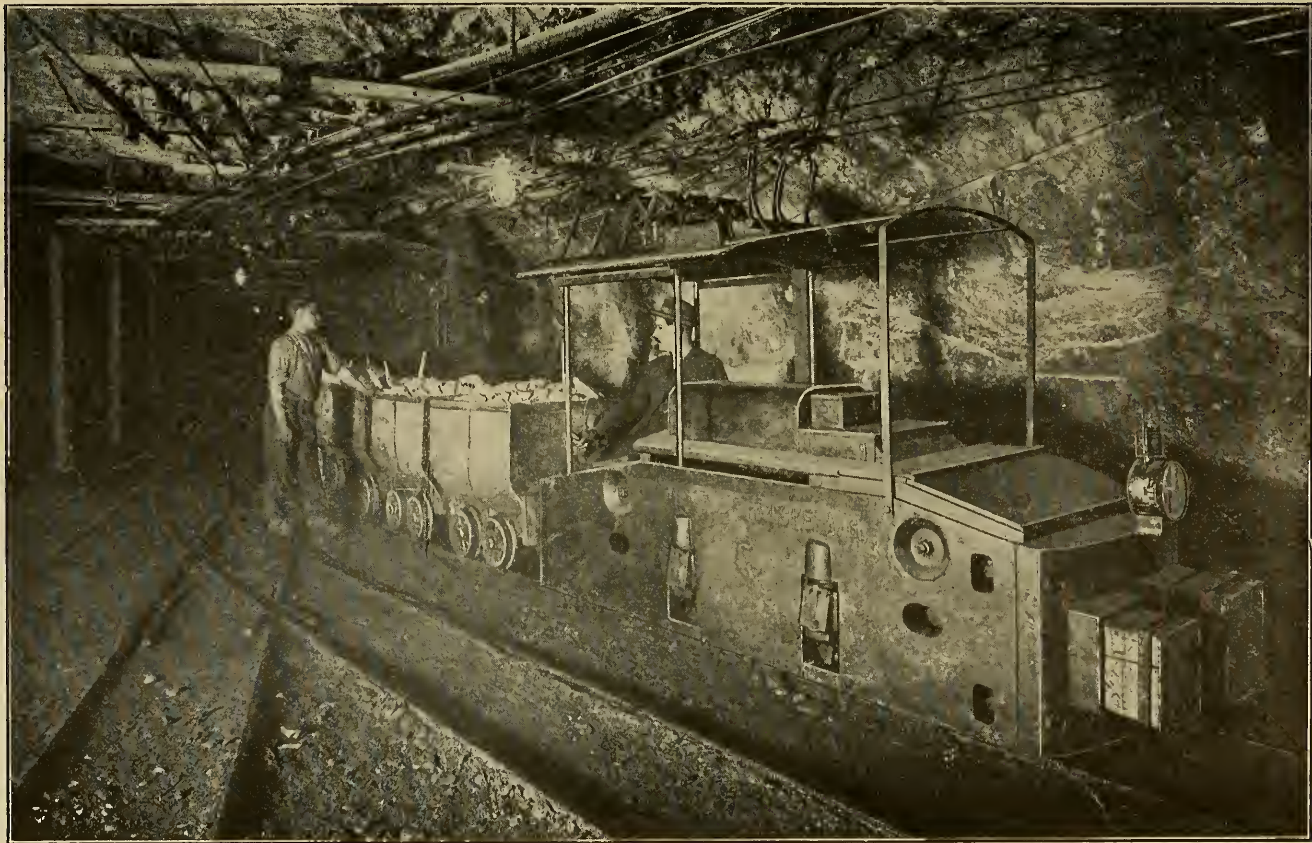
MINING KAINIT.

ELECTRICAL DRILLING MACHINE IN OPERATION.

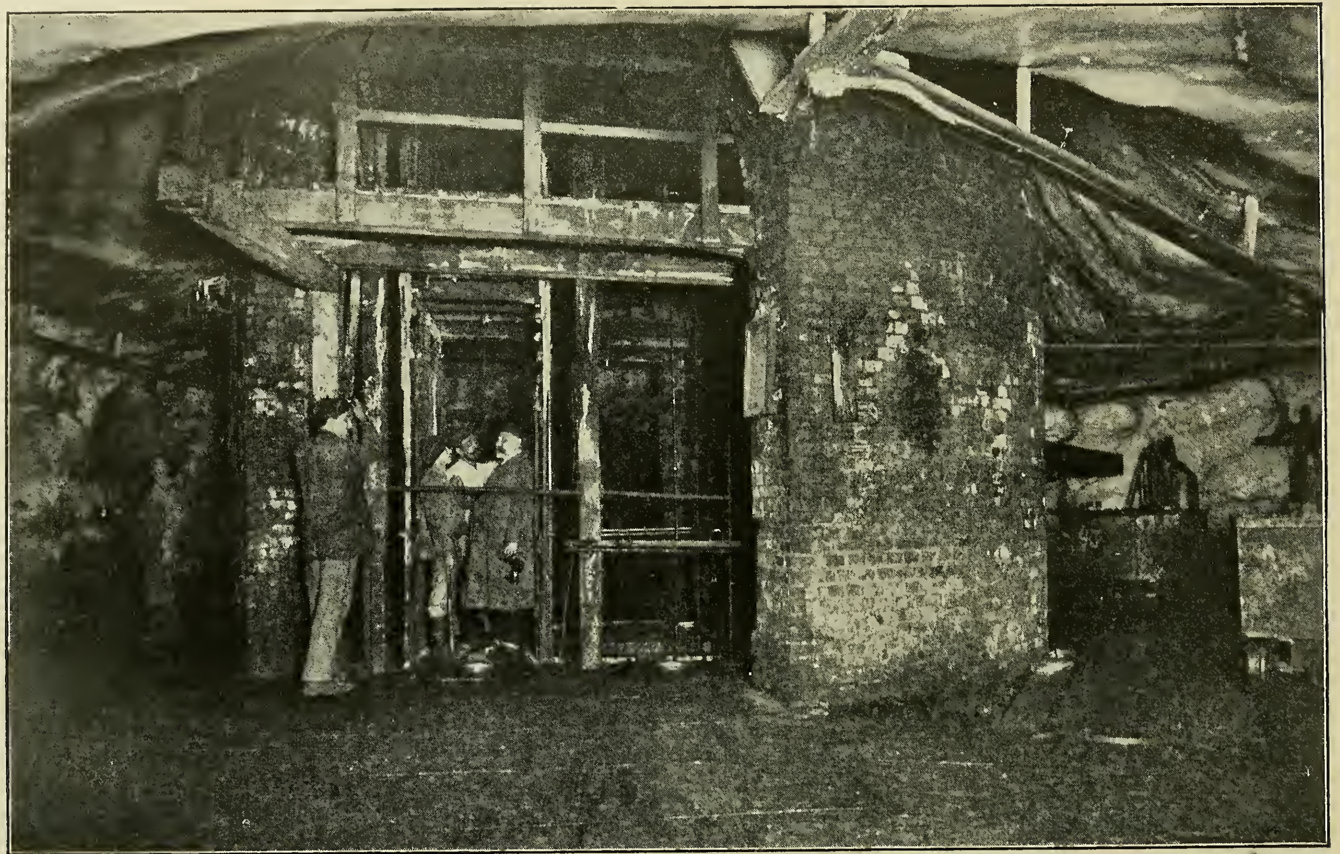


SCENE SHOWING MINING OPERATIONS.

TRANSPORTING POTASH SALTS IN THE MINES BY CABLE.



TRANSPORTING POTASH SALTS IN MINE BY ELECTRIC CONVEYANCES.



FOOT OF ELEVATOR SHAFT.

SCENE DURING LUNCH HOUR IN A POTASH MINE.

MANUFACTURING THE CONCENTRATED SALTS.

As has been intimated, at the mine-mouths are extensive and completely equipped chemical works which refine the crude salts and separate their constituents into products best suited to the various chemical industries. A most important feature of the refining is the reduction in weight by rejecting useless constituents of the salts, thus securing the valuable potash in a small bulk; an essential consideration for the man who pays the freight or handles the products. Yet to refine closely is an expensive process, and much study and great care are necessary to balance properly the amount of concentration against the diverse uses and the cost of shipping and handling the various materials. In estimating the quantity of potash in the different products, chemists are accustomed to make use of the term "actual potash," that is, oxide of potassium (K_2O). The object of this is to establish a basis of comparison of all potash salts; therefore, when "potash" is named in potash products, it is understood that the word refers to the amount of actual potash present, and not the quantity of sulphate or muriate of potash, as the case may be. As a matter of fact, potash is not sold commonly in the form of "actual potash" (K_2O), but as sulphate of

potash, muriate of potash, sulphate of potash-magnesia, etc. Sulphate of potash is simply actual potash combined with sulphuric acid; and muriate of potash, actual potash combined with muriatic (hydrochloric) acid.

In manufacturing muriate of potash from the crude minerals found in the Stassfurt mines, all lime, soda, magnesia and other salts are removed. Crude carnallit, as it comes from the mines, contains on an average 15 per cent. muriate of potash; the manufacturing process consists in separating this 15 per cent. from the 85 per cent. of other crude ores, and makes use of the chemical knowledge that these other salts are either more soluble or less soluble in water and other solutions than pure muriate of potash. The coarsely ground carnallit is "charged" into a large dissolving vat containing a boiling, saturated solution of magnesium chloride (a by-product of the process, as shown later). The mixture is agitated thoroughly by means of a "blow-up," or live steam jet, ~~and is~~ boiled until it shows a degree of concentration equal to 32 degrees Beaumé. The contents are then drawn off into settling tanks, from which the clear solution is run into crystallizing vats and left three or four days to cool and crystallize, the deposit containing about 60 per cent. pure muriate of potash. The liquors drawn from the crystallizing vats are boiled down (now almost exclusively in a vacuum apparatus, but formerly in open pans), during which process some chloride of sodium and sulphate of magnesium fall out. This second solution settles and runs into crystallizing vats where practically all

the potash separated as crystals of pure artificial mineral carnallit ($KCl, MgCl_2, 6H_2O$), which is treated precisely as was the crude carnallit and gives a nearly pure muriate of potassium in one crystallization.

The crystallized muriate of potash thus produced is contaminated by chlorides of sodium and magnesium, through adhereing solutions, and these impurities are removed by a series of washings with water. The liquor from these washings of the crystals is saved and used on fresh batches of the mineral ore. The crystals of muriate of potash are dried, after washing, and are from 70 to 99 per cent. pure (KCl). The last "mother liquors," or solutions from the crystallizing vats, (from which all the potash has been separated) are used for the manufacture of bromine and chloride of magnesium.

The muriate of potash (chloride of potassium) manufactured at Stassfurt is of various grades and contains actual potash in the following proportions:

PURE MURIATE OF POTASH.		ACTUAL POTASH.
70 to 75 per cent.	contains	46.7 per oent.
80 to 85 " "	"	52.7 " "
90 to 95 " "	"	57.9 " "
98 " "	"	62.0 " "

When sold for fertilizing purposes, it is on the basis of 80 per cent. pure muriate of potash, corresponding to 50.5 per cent. actual potash. The price is based on this average and is increased or decreased according to the percentage

above or below it of pure muriate contained, as shown by chemical analysis. Muriate of potash serves as a basis for the manufacture of many other potash salts, such as nitrates, chlorates, etc.

There are many by-products in the manufacture of muriate of potash, notably magnesium chloride and sulphate of soda, which later, owing to its purity and freedom from acid salts, is largely used in the manufacture of the cheaper grades of glass. From the residuum of the first solution of carnallit, treated with cold water, kieserit (sulphate of magnesia) settles out in fine crystalline particles, and is moulded into blocks. Large quantities of bromine and iron bromide are obtained at the end of the process. Some of the Stassfurt factories also prepare calcined magnesia, hydrate of magnesia, calcium chloride, carbonate of potash, carbonate of potash-magnesia, etc.

In order to obtain the complete extraction of potash, the processes of manufacture are complex, and solutions and salts require repeated handling. It naturally follows that the separation of commercially pure salts, from solutions of other salts, is an expensive process, and that it is only by the most painstaking care and full utilization of every possible by-product, that potash salts can be produced and sold at the present low prices.

Sulphate of Potash is manufactured in less quantities than muriate, owing to smaller demand for it in the market; but its consumption is rapidly increasing. There are several processes of manufacture. The one in general

use is to concentrate a solution of kainit to a certain specific gravity, and then allow it to cool slowly in large crystallizing vats. The resulting crystals are washed and dried, and from the commercial salt *sulphate of potash-magnesia*, containing generally 40 per cent. of sulphate of potash, but when calcined 48 per cent. In the manufacture of sulphate of potash a solution of sulphate of potash-magnesia and a given quantity of muriate of potash are boiled together, whereupon the less soluble sulphate of potash separates and falls as a precipitate, after which the solution is boiled down to a certain specific gravity, and cooled slowly in crystallizing vats, where the potash separates as crystals of sulphate of potash. As it is sold it varies from 90 to 96 per cent. pure, equivalent to 46 to 52 per cent. actual potash.

The tables on page 35 give the average analyses of the more important Stassfurt potash salts. The figures show the pounds of various substances in 100 pounds of the different salts.

The numerous by-products obtained in refining the crude potash salts are utilized in many ways and for various purposes. Some of them contain 20 to 30 per cent. actual potash, but in most cases in such combination as not to pay for necessarily expensive extraction. Because of this comparatively large content of potash, however, they are dried, calcined, pulverized, and mixed with crude salts, or other poorer forms of potash, to increase the potash content of these salts and give them added value for agricultural purposes.

Besides the agricultural, soil-restoring, plant-feeding use of potash salts, large quantities are consumed by the chemical industry in Germany, the United States and other countries, in the manufacture of carbonate of potash, caustic potash, nitrate of potash, chlorate of potash, chromate and bichromate of potash, alum, cyanide of potash, bromide of potash, permanganate of potash, yellow prussiate, and other compounds. The many sided technical and industrial activity of the age, in almost every trade, must have potash in one form or another. Doctors, photographers, painters, dyers, cleaners, bleachers, weavers, soap-makers and electricians use it, while the modern rapid, cheap production of artificial cold, of preservatives, fire-works, gunpowder, matches, paper, glass and aniline dyes, and the extraction of gold from its ores are impossible without it. While applications are thus without number, it is of greatest importance in agriculture in supplying plant food.

Crude Salts (Natural Products.)

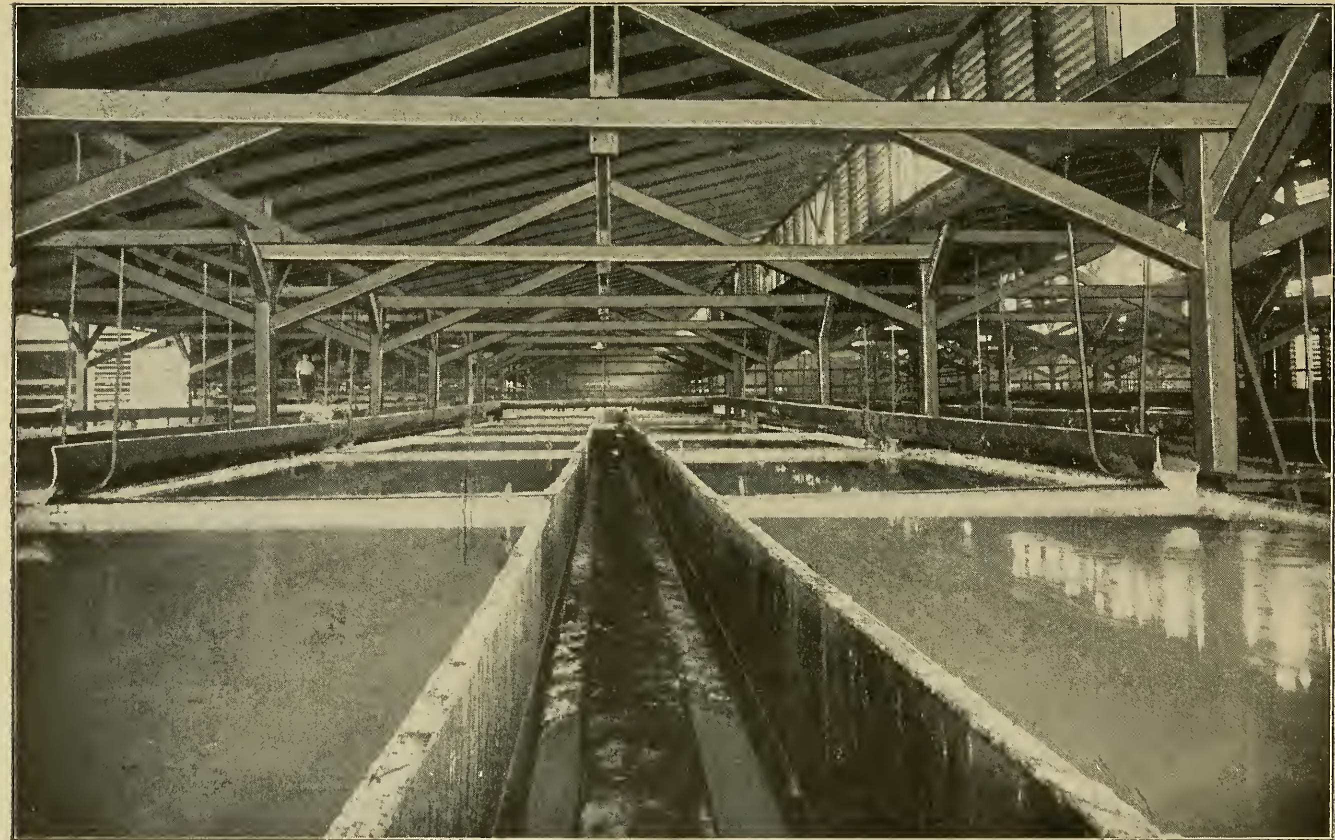
	KAINIT.	CARNALLIT.	SYLVINIT.
Actual Potash (K_2O)	12.8%	9.8%	17.4%
Minimum Guarantee (K_2O)	12.4%	9.0%	12.4%
Sulphate of Potash (K_2SO_4)	21.3%	.....	1.5%
Muriate of Potash (KCl)	2.0%	15.5%	26.3%
Sulphate of Magnesia ($MgSO_4$)	14.5%	12.1%	2.4%
Chloride of Magnesia ($MgCl_2$)	12.4%	21.5%	2.6%
Chloride of Sodium ($NaCl$)	34.6%	22.4%	56.7%
Sulphate of Lime ($CaSO_4$)	1.7%	1 9%	2.8%
Insoluble Substances	0.8%	0.5%	3.2%
Water	12.7%	26.1%	4.5%

Sulphates (nearly free of Chlorides.)

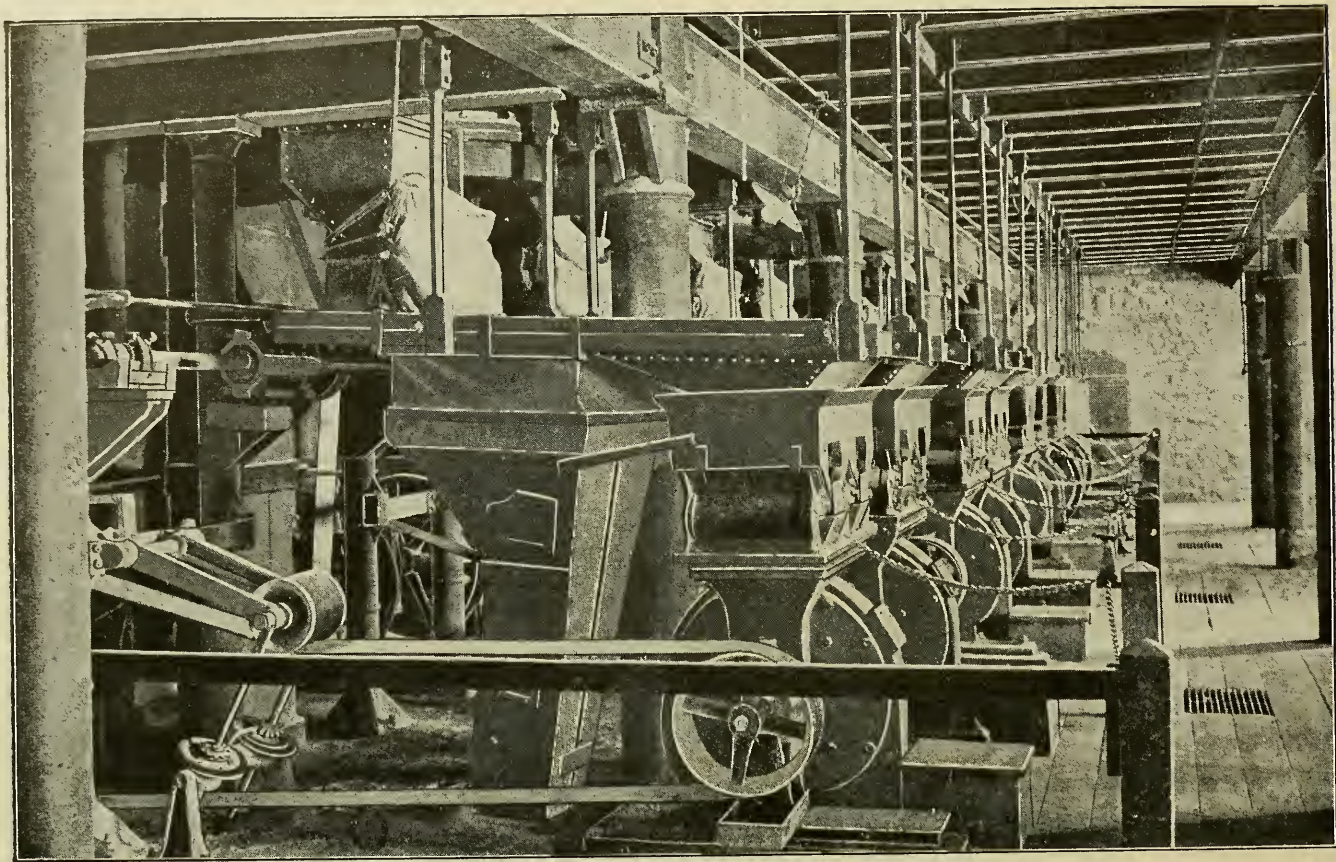
	SULPHATE OF POTASH.		SULPHATE OF POTASH-MAGNESIA.
	(90%)	(96%)	
Actual Potash (K_2O)	49 9%	52.7%	27.2%
Minimum Guarantee (K_2O)	48.6%	51.8%	25.9%
Sulphate of Potash (K_2SO_4)	90.6%	97.2%	50.4%
Muriate of Potash (KCl)	1.6%	0.3%	.....
Sulphate of Magnesia ($MgSO_4$)	2.7%	0.7%	34.0%
Chloride of Magnesia ($MgCl_2$)	1.0%	0.4%	.....
Chloride of Sodium ($NaCl$)	1.2%	0.2%	2.5%
Sulphate of Lime ($CaSO_4$)	0.4%	0.3%	0.9%
Insoluble Substances	0.3%	0.2%	0.6%
Water	2.2%	0.7%	11.6%

Salts Containing Chlorides.

	MURIATE OF POTASH.			POTASH MANURE SALTS.	
	90/95%	80/85%	70/75%	MIN. 20%	MIN. 30%
Actual Potash	57 9%	52 7%	46.7%	21.0%	30.6%
Minimum Guarantee	56.8%	50.5%	44 1%	20.0%	30.0%
Sulphate of Potash	.....	.....	1 7%	2 0%	1.2%
Muriate of Potash	91.7%	83.5%	72.5%	31 6%	47.6%
Sulphate of Magnesia	0.2%	0.4%	0 8%	10 6%	9.4%
Chloride of Magnesia	0.2%	0.3%	0.6%	5.3%	4.8%
Chloride of Sodium	7.1%	14.5%	21.2%	40.2%	26.2%
Sulphate of Lime	.....	.....	0 2%	2.1%	2.2%
Insoluble Substances	0.2%	0 2%	0.5%	4.0%	3 5%
Water	0.6%	1.1%	2.5%	4.2%	5.1%

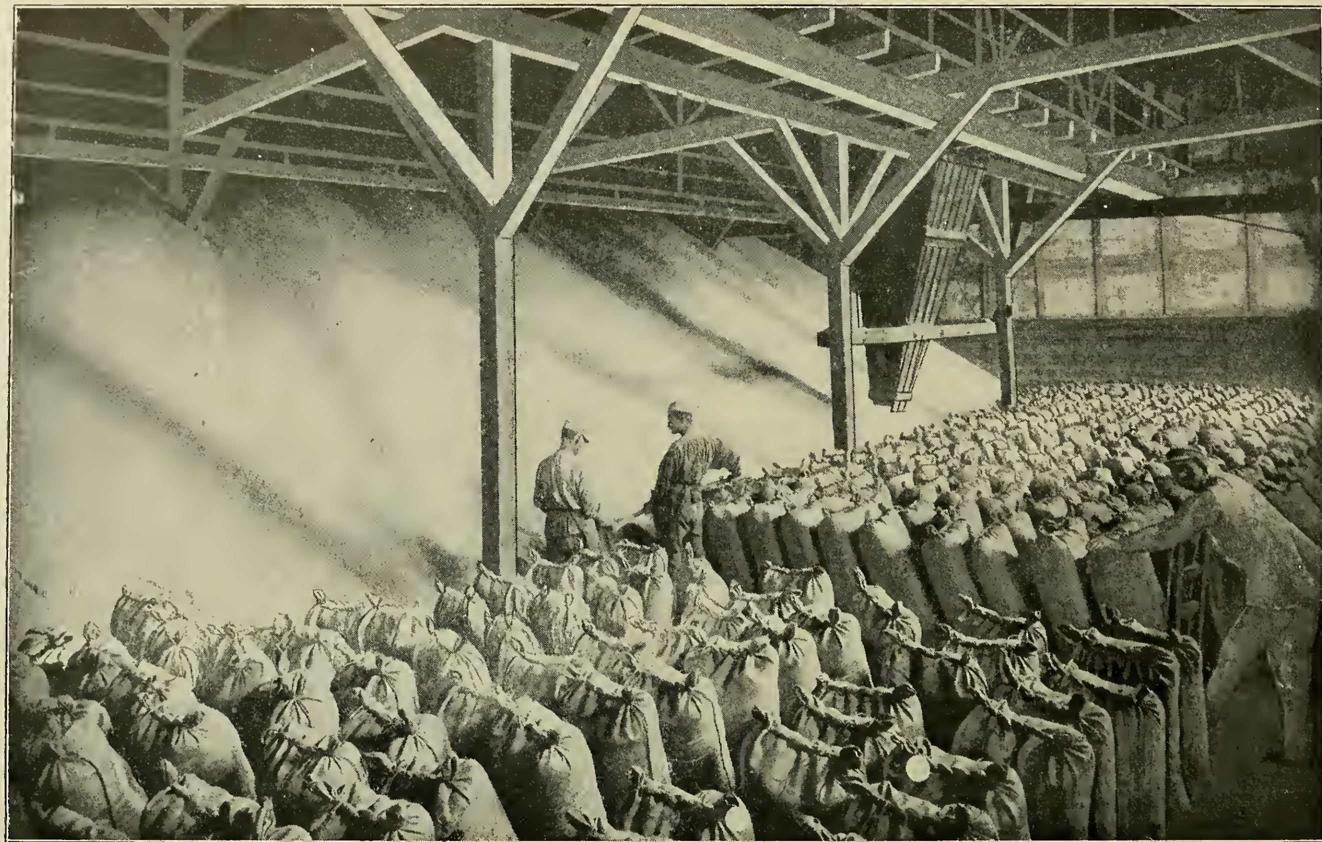


CHRYSTALIZING VATS.

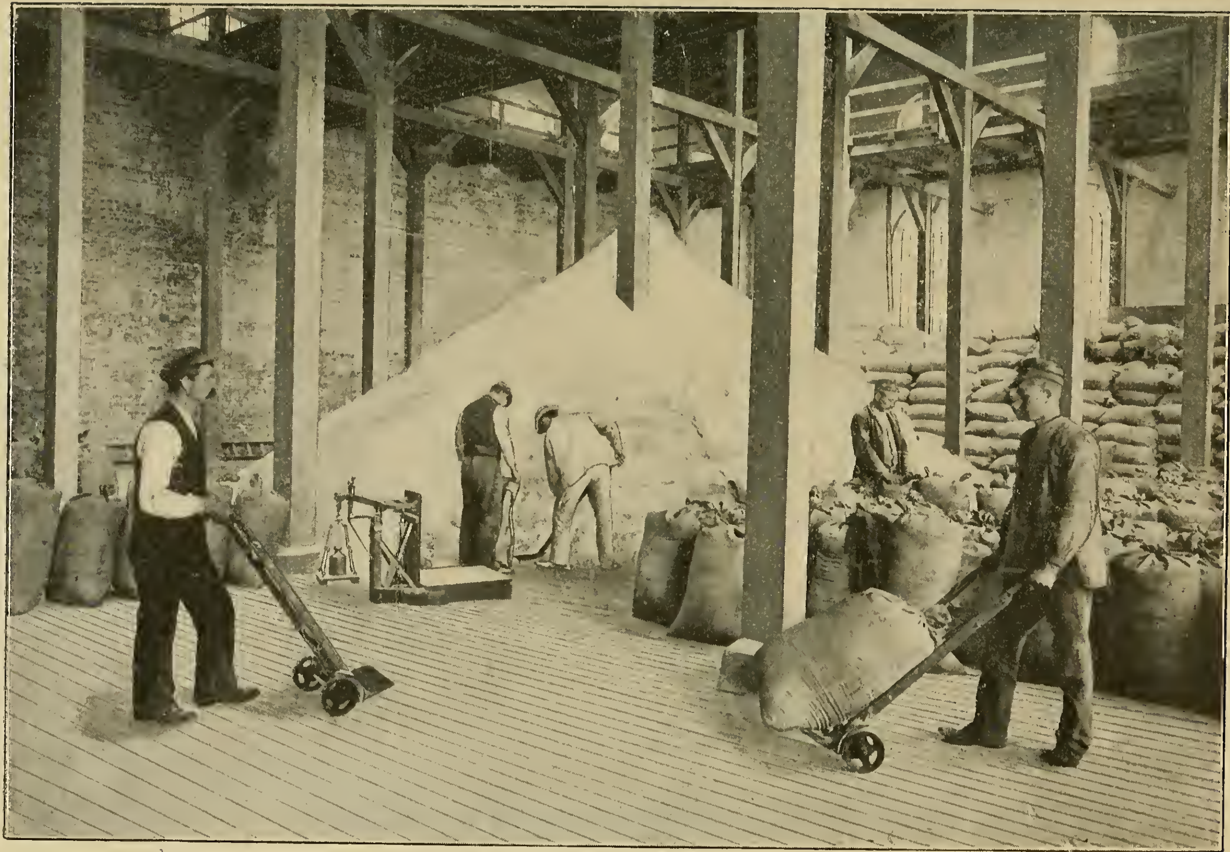


MILLS FOR GRINDING POTASH SALTS.

MILLS FOR GRINDING CRUDE POTASH SALTS.



BAGGING MURIATE OF POTASH.



BAGGING POTASH SALTS.

COMMERCIAL STATEMENT.

For fifty years the world's demand for potash has grown rapidly until to-day it is over five million tons per year, and the Stassfurt industry alone enables this demand to be satisfied.

Previous to the discovery of the Stassfurt deposits, potash, as used in the arts, was derived chiefly, as its name implies, from the leaching of wood ashes. The supply to be had from wood ashes and condensed hull ashes is limited. About 2,000 tons of muriate of potash are annually made in the south of France, by evaporating sea-water, and the Scottish manufacture of iodine from kelp yields perhaps 1,000 to 1,200 tons yearly of muriate and sulphate, as by-products. There are few other minor sources of supply, such as nitrate of potash from India, wool-washing residues (suint potash), and potash from beet sugar residues.

In 1884 the various mines producing potash were combined under a central office. The organization now includes forty-five mines:

This combination has about 270 executive officers, including representatives in foreign countries, while the mines themselves employ in round numbers, 1,300 officers and 30,000 laborers, and use 800 boilers and 900 steam engines with 75,000 horse power. Each of the works has its own railroad track, connecting with the main line, and, in some cases, this reaches a length of about 7½ miles, and most of the works have their own locomotives and railroad cars.

The daily output varies, but in the best seasons of the year, which are the spring and fall, it reaches as high as 2,300 carloads of ten tons each. The following table gives the production of crude salts, from the commencement of mining to the close of 1906.

Production of Crude Salts.

(Metric Tons of 2,204 lbs.)

YEAR	CARNALLIT.	ROCK KIESERIT.	SYLVINIT.	KAINIT AND HARTSALZ.	TOTAL.
1861	2,293	....	....	....	2,293
1862	19,727	20	....	....	19.747
1863	58,304	68	....	....	58.372
1864	115.409	89	....	....	115.498
1865	87,671	75	....	1,314	89,060
1866	135,554	414	....	5,808	141,776
1867	141,604	1,144	....	8,974	151,722
1868	167,337	1,418	....	10,772	179,527
1869	211,884	227	....	16,857	228,968
1870	268,226	71	....	20,301	288,598
1871	335,945	47	....	36,582	372,574
1872	468,538	23	....	18,067	486,628
1873	441,079	8	....	6,101	447,188
1874	414,961	16	....	9,753	424,730
1875	498,737	5	....	24,124	522,866
1876	563.669	145	....	17,938	581,752
1877	771,819	152	....	35,477	807,448
1878	735,750	520	....	34,004	770,274
1879	610,427	761	....	50,207	661,395
1880	528,212	893	....	139,491	668,596
1881	744,726	2,082	....	158,330	905,138
1882	1,059,300	4,658	....	148.477	1,212.435
1883	950,203	11,791	....	228,817	1,190,811
1884	739,959	12,389	....	217,107	969,455
1885	644,710	11,970	....	272,370	929.050
1886	698,229	13,918	....	247,327	959,474
1887	840 207	14,186	....	237,629	1,092,022
1888	849,603	10.754	2,220	375,574	1,238,151
1889	798,721	9,354	28,329	362,611	1,199,015
1890	838,526	6,951	31,917	401,871	1,279,265
1891	818,862	5,816	32,661	512,494	1,369,833
1892	736,751	5,783	32,669	585,775	1 360,978
1893	794,660	4,807	49,140	689,994	1,538,601
1894	851,339	3,865	63,495	729,301	1,648,000
1895	782,944	3,012	76,097	669,532	1,531 585
1896	856,223	2,841	90.390	833,025	1.782,479
1897	851,272	2,619	84,105	1,012,186	1,950,182
1898	990,998	2,444	94,270	1,120,616	2.208,328
1899	1,317,948	2,066	100,653	1,063,195	2,483,862
1900	1,697,803	2,047	147,791	1,189,394	3 037,035
1901	1,860,189	2,335	190.034	1,432,136	3,484,694
1902	1,705,665	1,821	188.821	1,354,528	3.250,835
1903	1,844,037	1,553	196,140	1,582,867	3,624,598
1904	1,911,166	1,056	234,455	1,906,823	4.053,500
1905	2,239,710	2,731	230,622	2 405,536	4,878,598
1906	2,263,197	9,191	284,944	2,754,572	5,311,903

These salts were either sold directly from the mines, for agricultural purposes, or manufactured into more concentrated potash products for use in agriculture, or in the arts and other manufactures. The table on page 43 shows the use made of the various salts, from 1880 to the close of 1906. The greater part of the crude salts, manufactured into concentrated products, was converted into muriate of potash. The following table gives, in metric tons of 2,204 pounds each, full detailed data as to the various concentrated salts produced from 1884 to the close of 1906.

Production of Concentrated Potash Salts.

(Metric Tons of 2,204 lbs.)

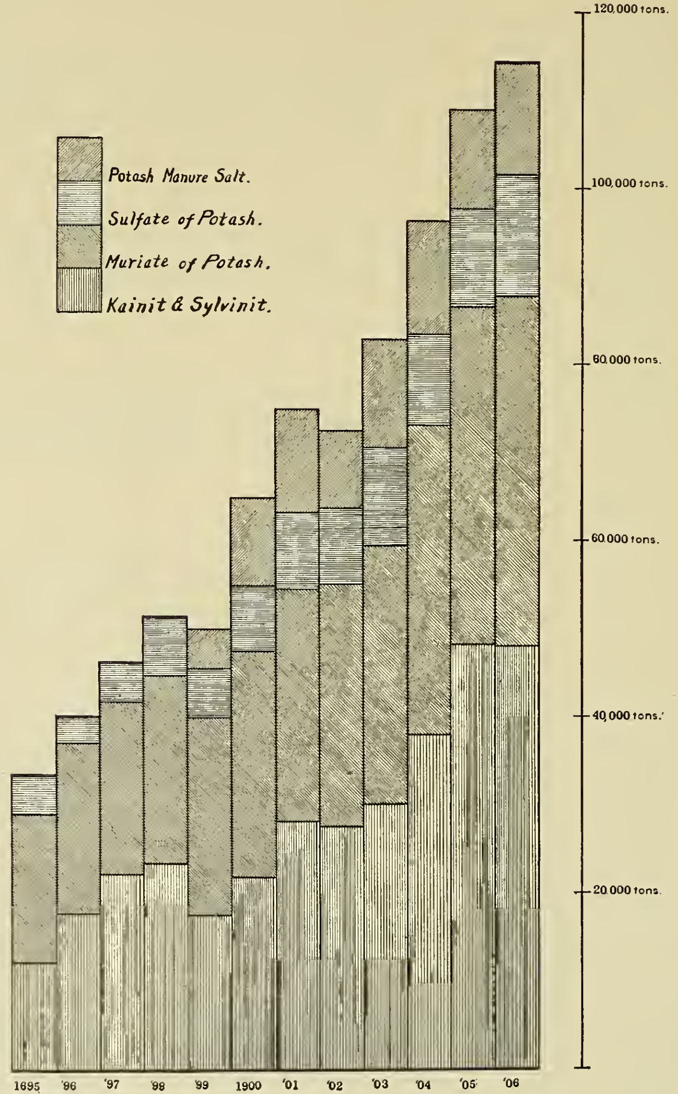
YEAR.	MURIATE OF POTASH 80 PER CENT.	SULPHATE OF POTASH 90 PER CENT.	SULPHATE OF POTASH-MAGNESIA.		POTASH MANURE SALT.	KIESERIT IN BLOCKS.	KIESERIT GROUND AND CALCINED.
			CRYSTALLIZED 40 PER CENT.	CALCINED 48 PER CENT.			
1884	106,330	3 000	400	8.000	9,500	17,800	....
1885	104,500	4,000	450	9,000	8,400	18,500	....
1886	110,200	3,639	475	10 111	8,161	19,500	....
1887	130,000	10,528	500	6,285	8,163	24,018	....
1888	132,000	10,916	522	11,380	13,918	28,325	....
1889	131,593	7,321	671	9,215	17,285	31,824	....
1890	134,760	13.839	907	10,830	17,620	32,005	....
1891	143,488	18,981	1,053	11,400	16,045	28.559	....
1892	121,028	15.466	708	11,842	16,895	23.855	11
1893	132,529	16,361	739	12,643	17.344	24,386	105
1894	147,936	15,243	1,780	12,718	19,728	26.440	216
1895	145,027	13.403	898	8 249	19,724	25,115	142
1896	155,805	13,889	1.051	4,622	19,253	24,987	211
1897	158,863	15,403	922	7,415	23,042	25.669	214
1898	174.380	17,781	914	10,535	24,284	19,934	728
1899	180.672	24,656	579	8,459	70,916	28.216	260
1900	206,471	31,255	932	12.150	129,863	28,508	358
1901	211,421	28,196	936	11,750	147 170	26.727	361
1902	191,039	30,202	600	16,834	139,329	26,809	767
1903	206,347	34,807	778	22.296	161,786	23,509	548
1904	235.298	39.447	775	27,672	196,860	26,471	463
1905	254,711	42,420	718	30.589	215 408	35,003	600
1906	279,320	51,198	834	37,110	278,325	29,411	632

Use made of Crude Potash Salts.

(Metric Tons of 2,204 Lbs.)

YEAR.	CARNALLIT AND ROCK KIESERIT.				KAINIT AND SYLVINIT (INCL. HARTSALZ).			
	FOR AGRICULTURAL PURPOSES.		FOR MANUFACTURING CONCENTRATED SALTS.	TOTAL.	FOR AGRICULTURAL PURPOSES.		FOR MANUFACTURING CONCENTRATED SALTS.	TOTAL.
	GERMANY.	ALL OTHER COUNTRIES.			GERMANY.	ALL OTHER COUNTRIES.		
1880	4,137	....	524,968	529,105	23,769	103,749	11,973	139,491
1881	6,902	....	739,906	746,809	20,372	119,491	18,467	158,330
1882	10,249	....	1,053,709	1,063,958	30,414	95,263	22,800	148,477
1883	17,434	....	944,560	961,994	48,138	153,200	27,479	228,817
1884	18,654	....	733,694	752,348	48,644	109,656	58,807	217,107
1885	18,988	....	637,692	656,680	50,870	143,518	77,982	272,270
1886	22,729	....	689,418	712,147	65,835	105,050	76,441	247,326
1887	30,892	....	823,501	854,393	84,493	89,294	63,842	237.629
1888	31,776	....	828,580	860,356	105.237	142,171	130,386	377,794
1889	37,746	382	769,947	808,075	150,342	113,109	127.489	390.940
1890	34 574	373	810,530	845,477	178,031	126,984	128,772	433,787
1891	38,893	551	785,234	824,678	240,001	173,508	131,647	545,156
1892	45,367	1,253	695,913	742,533	366,661	131,912	119.871	618,444
1893	59,464	3,483	732,233	795,180	428,891	184,358	125,885	739,134
1894	60,893	4,117	790,195	855,203	466,208	200,240	126 348	792,796
1895	50,528	3,836	731,582	785,946	436,923	190,732	117,975	745,630
1896	56.541	3,964	798,560	859,065	557,527	245,660	120,829	923,416
1897	58,544	5,157	790,190	853,891	668,340	295,765	132,185	1,096,290
1898	60.793	7,189	925.461	993,443	722,115	334.111	158,660	1,214,886
1899	58,677	4,611	1,256,730	1.320,018	717,637	314,869	131,342	1,163.848
1900	55,489	2,869	1,641,493	1,699,851	724,624	375,007	237,554	1,337,185
1901	77,862	7,382	1,777,280	1,862 524	859.115	494.220	268,835	1,622,170
1902	89,127	7,933	1,600.425	1,707,486	854,753	451,699	245,977	1,543.349
1903	73,092	3 473	1,769.025	1,845,590	978,670	486.853	313,488	1,779,008
1904	75,680	4,853	1,831,690	1,912.222	1,202.587	544,091	394,601	2,141,278
1905	69,107	2,739	2,170,595	2,242,441	1,267,989	742,544	625.624	2,636,158
1906	65,174	2,105	2,205,109	2,272,388	1,407,553	819,090	812,872	3,039,516

Consumption of Potash Salts in United States
1895 to 1906 inc.



The chart on page 44 illustrates the consumption of the various Potash salts in the United States for the years 1895 to the end of 1906 and shows the progress of Potash consumption made during that time.

The greater part of the total potash production as has been before stated, is used for agricultural purposes,—that is, as food for plants, as the following table, giving the total amount of actual potash consumed in agriculture and in the arts during the years 1890, 1900 and 1906 will show:

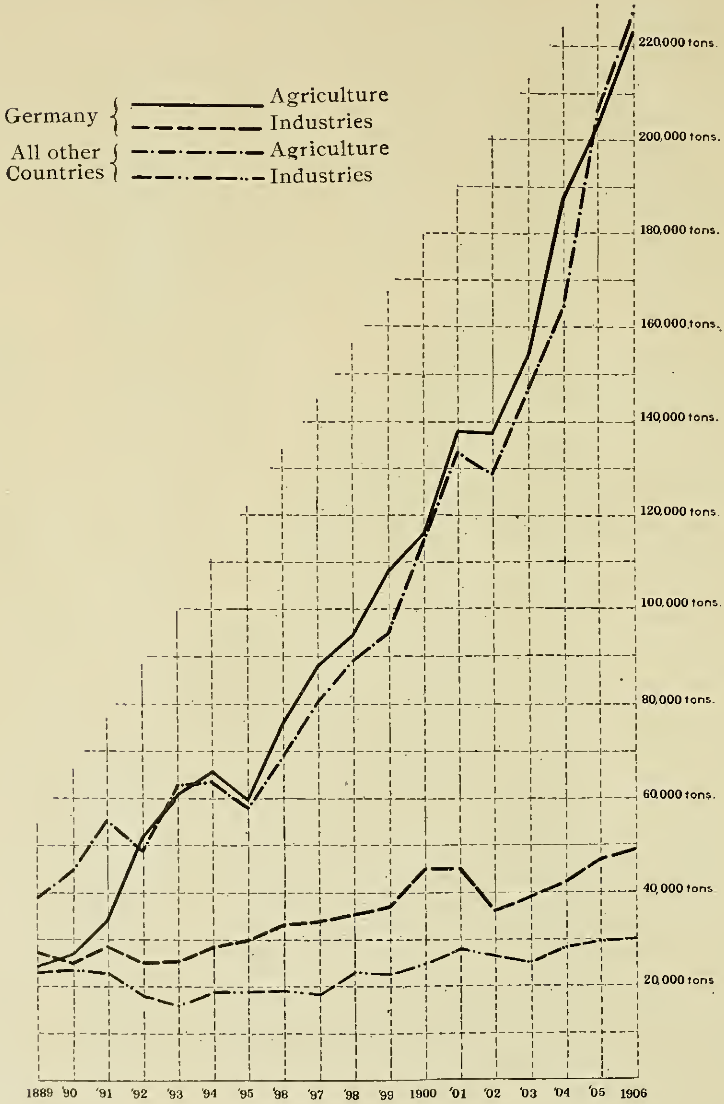
	1890 TONS.	1900 TONS.	1906 TONS.
Potash used for agricultural purposes,	71,456	232,820	470,424
Potash used for industral purposes,	50,846	70,790	77,167

The diagram on page 46 is designed to show graphically the relative consumption of actual potash (K_2O) in agriculture and in the industries during the years 1889 to 1906.

The consumption of potash in different countries is best shown by the table on page 47 giving amounts of "actual potash" used in each case, on the basis of a ton of 2,204 pounds. The table on page 48 points out the consumption of actual potash in pounds per 100 acres of cultivated land. This is shown graphically in the diagram on page 49. Incidentally but strikingly it indicates the actual progress in agricultural development of the different countries.

This relatively small consumption by the United States according to this table is scarcely a just comparison. Much of the cultivated land in this country has, in the past, been "new" or "virgin" soil, to which no regular applications of plant food have been supplied.

A Comparison of Amounts of Actual Potash used in Agriculture and the Industries.



Consumption of Potash in the Agriculture of the most important Countries.

Total consumption in Metric Tons of pure Potash (K_2O)

COUNTRY.	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906
Germany	59,800	75,114	89,184	95,965	107,273	117,211	137,314	137,277	153,631	187,919	202,109	228 485
United States	33,907	40,543	46,628	51,663	50,182	65,152	75 053	72,739	82,970	96,536	109,091	132,249
Belgium	2,881	2,681	2,829	3,110	3 367	3,607	6,304	3,266	4,618	5.770	9,341	8 376
Holland	2,542	2,964	4,091	5,032	6 021	7 106	9.370	8 605	10,250	11.452	17,329	19 452
France	5.033	5,892	7,308	6.532	8,772	8,229	6.285	4,938	9,324	9 285	11,204	15,465
England			3,165	3,871	4,014	4.020	4,212	4,683	5,813	6,390	8 745	8,721
Scotland	4 088	4,569	1,487	1,782	2,584	3,370	3,752	4 653	4 370	4,846	5,630	5 792
Ireland			297	285	412	600	705	570	1,035	1,228	1,626	2.111
Austria	1 035	1,176	1,319	1 590	2,208	2,281	3,291	3,177	3,650	4.885	5,778	6,841
Hungary	10	20	30	40	48	108	245	318	356	549	470	667
Switzerland	833	876	953	931	1,038	1,026	1,691	728	1,426	1,447	1 327	1,541
Italy	851	792	938	1,235	1,197	1,379	1,306	1,447	1,522	1,925	2,308	2,819
Russia	467	620	625	1,011	1,037	1,597	2,079	2 486	1,916	2.176	2 539	2,515
Spain	369	456	770	1 128	1,953	2,428	2,498	1,552	2,841	3 078	3,185	4,133
Portugal	68	46	44	119	13	43	55	67	111	208	259	348
Sweden	5,061	5 719	6,869	7,637	6.892	8 197	9,303	11,011	9,096	11,222	14,391	16,434
Norway	69	107	164	252	238	286	320	432	526	691	975	1,273
Denmark	833	1.071	1,030	1,375	1,320	1,692	2,499	2,415	2,391	1,889	3,880	4,469
Finland	181	331	466	566	505	382	512	880	353	250	429	667
Other Countries	1,075	806	1.344	1.339	3.517	4,106	3,379	5.212	5,218	6.941	6,542	8,058

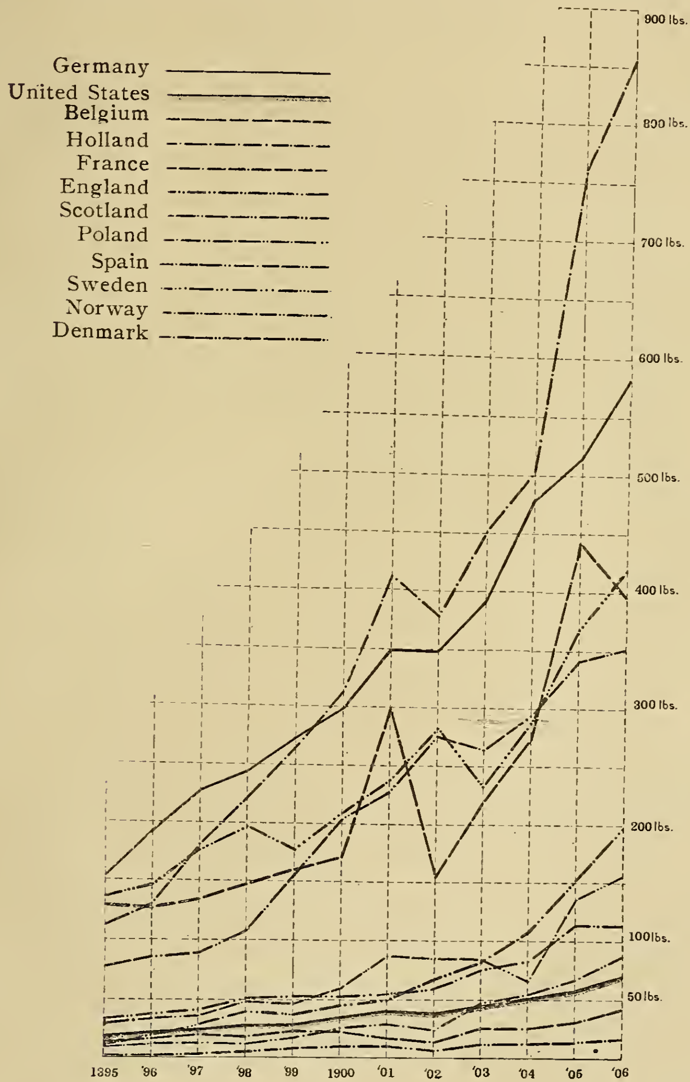
Consumption of pure Potash (K_2O) for Agricultural Purposes in different Countries.

(Calculated in lbs. per 100 acres arable land.)

COUNTRY.	Arable Land including Pastures in Acres.	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906
Germany	86,625,399	152.2	191.2	226.9	244.2	273.0	298.3	349.4	349.3	391.0	478.2	514.2	581.4
United States....	414,491,441	18.0	21.6	24.8	27.5	26.7	34.6	39.9	38.6	44.2	51.4	58.0	70.3
Belgium	4,659,506	136.3	126 8	133.8	147.1	159.2	170.6	298.2	154 5	218.5	273.0	441.9	396.2
Holland..........	5,012,379	111.8	130.3	179.9	221.3	264.7	312.5	412.0	378.4	450.7	503.6	762.0	855.4
France...........	81,099,031	13.6	16.1	19.9	17.8	23.8	22.4	17.0	13.4	25.3	25.2	30.4	42.0
England...	16,916,409	33.3	37 2	41.2	50.4	52.3	52.4	54.9	61.0	75.7	83.2	113.9	113.6
Scotland.........	3,641,413	77.3	86.3	90.0	107.8	156.5	204.0	227.1	281.7	264.5	293.4	340.8	350.6
Ireland...........	5,322,749	10.6	11.9	12.3	11.8	17.0	24.8	29.2	23.6	42.8	50.8	67.3	87.4
Austria	35.362,182	6.4	7.3	8.2	9.9	13.7	14.1	20.5	19.9	22.7	30.4	36.0	42.6
Hungary.........	42,863,206	0.05	0.11	1.25	0.21	0.18	0.55	1.2	1.6	1 9	2.8	2.4	3.4
Switzerland......	5 524,391	33.3	35 0	38.0	37.1	41.4	40.9	67.5	29.1	56.9	57.7	53.0	61.5
Italy..............	50,010,122	3.7	3.5	4.1	5.4	5.3	6 1	5.8	6.4	6.7	8.5	10.2	12.4
Russia............	318,621,904	0.36	0 45	0.45	0.71	0.71	1.1	1.4	1.7	1.3	1.5	1.8	1.8
Spain.............	54,405,467	1.5	1 9	3.1	4.5	7.9	9.8	10.1	6.3	11.5	12.5	12.9	16.8
Portugal.........	11,329,499	1.3	0.9	0.9	2.3	0.27	0.8	1.1	1.3	2.1	4.0	5.1	6.8
Sweden..........	8,622,409	129.3	146.2	175.5	195.2	176.2	209.5	237.8	281.5	222.5	286.9	367.9	420.1
Norway..........	1,412,975	10.7	16.7	25.7	39.3	37.1	44.7	49.9	67.3	82.1	107.8	152.2	198.6
Denmark	6,305.259	29.2	37.5	36.0	48.1	46.1	59.1	87.4	84.4	83.6	66.0	135.7	156.2
Finland..........	2.755,277	14.5	26.6	37.3	45.3	40.4	30.6	40.9	69.8	28.2	20.0	34.3	53.3

Relative Consumption of Actual Potash in Fertilizers in Different Countries.

(Shown on basis of pounds per 100 acres arable land.)



THE IMPORTANCE OF POTASH IN AGRICULTURE.

What has been already broadly stated merits closer and detailed observation and study. Crop after crop taken from the same soil, gradually, but nevertheless surely, exhausts it. The yields diminish from year to year, until a point is reached where once rich and paying lands are tilled at a loss or abandoned to weeds. Mark the contrast in twenty years of gradually shrinking yields in all directions. A single example will suffice here. In 1870 the average potato yield was 86.6 bushels per acre; in 1890 it was but 55.8 bushels. This gradually but surely diminishing productiveness is not confined to one country, but prevails universally wherever manure or fertilizers are not employed to replace what is removed by crops. This failing, commonly called "wearing out" of the soil, is now known to be due to exhausting its "plant food," which is the usual term used in speaking of the chemical substances necessary to plant growth. The three essential plant food ingredients are phosphoric acid, nitrogen and potash; and everyone dependent upon the soil for a living needs to become thoroughly familiar with them, and their sources of supply and relative values. Commercial fertilizers derive their values from the percentage of these three essential ingredients which they contain. This word "essential" is deliberately and ac-

curately used in speaking of all three of these, which fact must not be forgotten in noting how much space is given, in this work, to the necessity for potash. The chief effect of potash in plant life and activity appears to be in the formation of starch and the development of the woody part in stems and stalks, and the pulp and sugar in fruit. The amount required for the proper and best development of a crop depends upon the nature and weight of that crop. Different growing plants have different appetites and necessities for potash and the amount of it which they have taken away from the soil can be accurately ascertained by chemical analyses. The following table shows the number of pounds per acre removed by an average yield of:

Grain and Hay in rotation,	75 lbs.	potash.
Oats, ...	62 "	"
Potatoes, . . .	74 "	"
Sugar Beets, . . .	143 "	"
Meadow Hay, . . .	85 "	"
Green Corn, . . .	164 "	"
Tobacco, . . .	103 "	"

A common four-year rotation of crops in the northern states is corn, wheat, clover, timothy. By it the amount of potash taken from each acre is:

Corn,	yielding 52 bushels,	82 lbs.	Potash.
Wheat,	" 25 "	22 "	"
Clover,	" 2¼ tons,	120 "	"
Timothy,	" 2 "	94 "	"
		Total—318 lbs.	Potash.

This loss of 318 lbs. of actual potash means an average of 80 pounds each year, or an equivalent of 160 pounds of muriate of potash. This must be replaced in the form of manure or fertilizer, or poverty of soil rapidly follows.

Where the fodder is fed to cattle, and the manure returned to the soil, part of the potash contained in the crop is returned to the soil. If, on a farm of 100 cultivated acres, one third of the required potash be thus returned (considerably more than usually is saved in ordinary farming), there still is 5,000 pounds of it annually removed from the farm, which must be replaced by some form of potash fertilizer, otherwise the original condition and richness of the soil cannot be maintained. More or less potash is naturally present in all soils, but, for the most part, in an insoluble and unavailable form, excepting that very small part which is freed and made accessible by the action of the elements. Even this original natural supply is very limited, and were it all at once to be rendered soluble, it would quickly be leached out by rains and so completely lost.

In the beginning of vegetation easily soluble potash is absolutely essential, but it is not generally present in such form even in soils which contain a fair supply of it. The importance of potash salts in agriculture, therefore, is evident: farmers must use them to make good the losses due to the growing and selling of crops. In this connection it is worthy of especial note that a part of the fertilizing substances contained in barnyard manure is insoluble, and so unavailable,—useless as plant food. This has been practi-

cally demonstrated by long, careful tests made at the Experiment Station at Rothamsted, England. For 42 years a section of land was treated with farmyard manure at the rate of 14 tons per year; during the same period an equal section, of the same character, received chemical manures. The actual plant food applied per acre each year in each case, and the average yield of wheat was:

	IN FARMYARD MANURE.	IN CHEMICALS.
Nitrogen,	200 lbs.	110 lbs.
Potash,	160 lbs.	100 lbs.
Phosphoric Acid,	110 lbs.	87 lbs.
Yield of grain,	32.25 bushels.	39.75 bushels.

The plant food in the farmyard manure, though applied in great excess, as compared with the chemical manures, failed to give as good results. This was undoubtedly because a large part of the potash and phosphates in the farmyard manure was unavailable, and could not be fed upon by the growing plants.

Scientists and practical farmers agree that the by-products of the farm (farmyard manure) returned to the soil, are not sufficient to keep it fertile, and the loss by cropping must be made good by applying chemicals :—nitrogen, in the form of nitrate of soda, sulphate of ammonia, tankage, fish scraps, etc., or by growing cow peas, clovers and other legumes, which absorb nitrogen from the air. The main source of the potash supply is the Stassfurt potash salts, while mineral phosphates and bone products are depended on for phosphoric acid. Chemical manures have an advan-

tage over those of the farmyard, in that they are readily available, cheaper and more agreeable to handle, besides being free from weed seeds and disease germs, which sometimes occur in the farm products.

In 1900 the United States consumed a total of about 2,600,000 tons of fertilizers, having an average composition of 2 per cent. ammonia, 3 per cent. actual potash and 9 per cent. available phosphoric acid. Thus, the consumption of the three necessary elements of plant food,—potash, nitrogen and phosphoric acid was:

Nitrogen, ...	52,000 tons.
Potash, ...	78,000 "
Phosphoric Acid, ...	234,000 "

To show the number of pounds of potash taken from the soil for each 100 pounds of phosphoric acid, a table of the leading crops is here given. 100 pounds of phosphoric acid is taken as the basis, and the comparison shows the probable exhaustion of potash in the soil.

CROPS.	PHOSPHORIC ACID.	POTASH.
Wheat,	100 lbs.	246 lbs.
Corn,	100 "	173 "
Timothy,	100 "	378 "
Clover,	100 "	456 "
Barley,	100 "	335 "
Potatoes,	100 "	219 "
Tobacco,	100 "	475 "
Cotton,	100 "	325 "
Oats,	100 "	250 "
Average,	100 lbs.	318 lbs.

For every 100 pounds of phosphoric acid taken from the soil, the average is 318 pounds of potash. According to this, instead of using only 125,000 tons of actual potash, the farmers of the United States should have used about 744,120 tons,—in order to replace that which was taken from the soil by the growing crops in a single year.

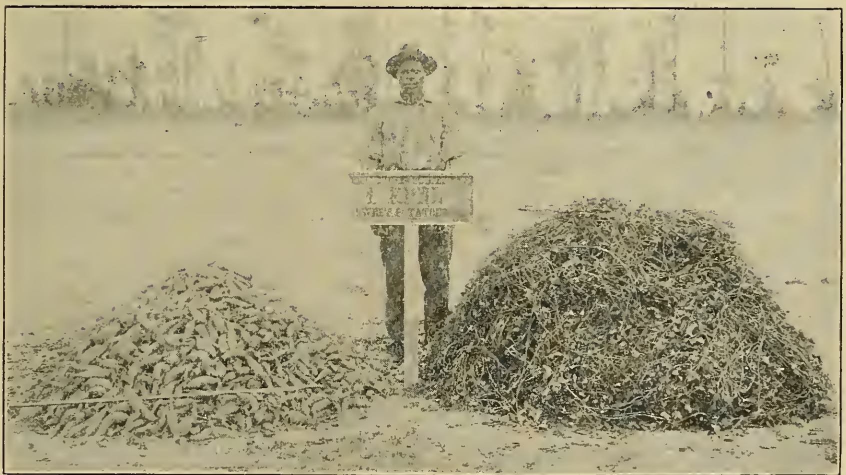
The plant food represented in the above figures is based on actual fertilizer consumption:—the 234,000 tons of phosphoric acid were undoubtedly needed, and the 744,120 tons of potash just as much so.

ARTICHOKES, WITHOUT FERTILIZER.

ARTICHOKES, FERTILIZED WITH POTASH, PHOSPHORIC ACID AND NITROGEN,

EXPERIMENTS MADE AT SOUTHERN PINES, N. C.

SWEET POTATOES FERTILIZED WITH PHOSPHORIC ACID AND NITROGEN. YIELD PER ACRE: 122½ BUSHELS.



SWEET POTATOES, FERTILIZED WITH POTASH, PHOSPHORIC ACID AND NITROGEN. YIELD PER ACRE: 250 BUSHELS.

EXPERIMENTS MADE AT SOUTHERN PINES, N. C.


NO
FERTILIZER
F.G.DORMAN
FREDONIA
N.Y.
POTASH
PHOSPHORIC
ACID
NITROGEN
PHOSPHORIC
ACID
NITROGEN


R.C. HART
WALDEN
N.Y.
NO
FERTILIZER
YIELD
105 BU. PER ACRE
POTASH
PHOSPHORIC ACID
NITROGEN
YIELD
155 BU. PER ACRE
PHOSPHORIC ACID
—AND—
NITROGEN
YIELD
120 BU. PER ACRE

POTASH SALTS FOR FERTILIZING.

The most important of the potash salts used and in demand for agricultural purposes, with their percentages of actual potash, are :

	PER CENT. ACTUAL POTASH.	POUNDS ACTUAL POTASH PER TON OF 2,000 LBS.
Muriate of Potash,	50	1,000
Sulphate of Potash,	50 to 55	1,000 to 1,100
Sulphate of Potash-Magnesia,	27 to 30	540 to 600
Kainit,	12½	250
Manure Salt, min. 20%,	20 to 21	400 to 420

The practical farmer is frequently confronted with the question : "Which of these potash salts shall I use, and how must I apply to get the best results?" the following explanations and suggestions help him to answer.

Muriate of Potash is the cheapest source of potash particularly in sections remote from the sea ports. This is because it is a concentrated article. One half of its weight is pure potash, and it relatively costs much less in transportation than those products containing greater bulk and weight, but a lower percentage of potash. Muriate is the principal source of potash employed in commercial fertilizers and is well suited for most agricultural crops. It contains considerable chlorine (46 per cent.) which substance is considered injurious to the quality of smoking tobacco, for which crop sulphate of potash, although higher in price, should always be used. Many farmers likewise use sulphate in preference to the muriate on oranges, sugar cane, potatoes, fruits and tender vegetables, believing that the better quality produced compensates for the greater cost.

However, deleterious effects on quality of the product can usually be avoided by applying the muriate of potash several months preceding the planting of the crop. By this previous application, the injurious chlorine contained in the muriate of potash is washed down by the rains into the subsoil, while the valuable constituent, potash, remains fixed in the surface-soil until it can be made use of by the growing plants. When muriate of potash is used regularly as a source of potash, it is desirable that the land receive a dressing of lime about once in five years. This will heighten the effect to the muriate.

Sulphate of Potash, and Sulphate of Potash-Magnesia. These potash salts, especially the first mentioned, are the safest potash fertilizers to use under all conditions. The sulphate is always preferred to tobacco growing, also for oranges, sugar cane and tender vegetables. It deserves preference on soils inclined to be sour, and can be used in large quantities, for years in succession, without necessitating the use of heavy applications of lime, which are needed when muriate or kainit is extensively used. Sulphate of potash is the most expensive source of potash, and for this reason is not as universally used as the muriate of potash.

Manure Salt is another source of potash, of which it contains 20 per cent. It is similar in its effect to kainit and may be used instead, but neither one is recommended for tobacco, oranges, or in any case where there would be objection to muriate; in all such cases sulphate of potash should be taken.

Kainit, as previously explained, is a raw product and contains only one-fourth as much actual potash as the muriate of potash. It is much cheaper per ton, though the potash in it costs more pound for pound than in the muriate, because of the freight, which has to be paid on the whole mass regardless of the potash contained in it. It is frequently preferred to the muriate on account of its marked effect in ridding the soil of injurious insects, (cut worms, white grubs, onion maggots, etc.). It is also highly esteemed in the cotton-producing states as a valuable preventive or remedy in "cotton blight." Mangel wurzel and other cattle beets and asparagus are particularly benefited by kainit. It is most effective as a preserver of stable manure, and many practical farmers, though knowing that muriate of potash is cheaper, still prefer the kainit, because it is less concentrated, and requires less caution in mixing with other fertilizers and making composts. In sections remote from the sea ports it may be so expensive (because of freight) as to make muriate of potash decidedly more economical. General experience has taught that on light soils its effects are very beneficial, but on heavy ones muriate of potash is to be preferred.

The following table is arranged in two groups to distinguished between those which contain chlorides and those which do not :

CONTAINING CHLORIDES.	FREE OF CHLORIDES.
Muriate of Potash.	Sulphate of Potash.
Kainit.	Sulphate of Potash-Magnesia.
Manure Salt.	

Those in the first group can be used with safety upon most agricultural crops, whereas those of the second should have preference for tobacco, oranges, or wherever special quality of fruit is essential, and wherever the more valuable result or return will justify the use of the higher priced fertilizer.

As previously explained, potash is only one of the three essential plant food ingredients; the others are phosphoric acid and nitrogen, and all three are of equal importance in plant life. To make potash fully effective as a fertilizer, it is necessary to use it jointly with phosphoric acid and nitrogen, each in proper proportion. No one of these three ingredients can take the place of another in plant feeding, nor can an excess of any one compensate for a deficiency of a second. Potash salts should not be used alone, except in rare cases when soils are so rich in phosphoric acid and nitrogen, as compared with potash, that the latter alone is needed. In most cases, however, in order to produce the best effects, it is necessary to use potash salts jointly with material supplying phosphoric acid (acid phosphate, etc.) and nitrogen (nitrate of soda, fish and meat refuse, cottonseed meal and others). A mixture of these three ingredients is called a "complete fertilizer," and complete fertilizers, as sold in the market, contain potash, phosphoric acid and nitrogen in different proportions to meet the demands of the various crops. Each farmer, therefore, must be governed by his particular needs in buying fertilizers. The value of the fertilizer, as already pointed out, depends entirely on the

amount of potash, phosphoric acid and nitrogen it contains. If potash is bought separately, then the other two necessary plant food ingredients must be supplied also, or else that which is supplied may be a practical waste and all crops fail. In the rational use of fertilizers, close attention must be given to the nature of the soil upon which they are to be used, since soils differ even from one season to another, depending on the preceeding crops grown and what they have removed from the soil as well as on its original formation and composition. All this must be made a careful study on the part of the farmer if he wishes to apply fertilizers to the best advantage and greatest profit.

In conclusion every farmer is advised to study the work of the Experiment Stations in the different States, as they have been established for the purpose of carrying on practical field trials to find out which combinations of plant food are best suited to the various soils and crops. The results are of value and importance to all those who earn their living by tilling the soil. Time, money and labor can be saved in this way, but the real progressive farmer will not only keep himself informed about the experience of others, but will also, to a certain extent, experiment on his own account, to learn which methods of cultivation, rotation and fertilization can be practiced with the greatest benefit and profit to himself. But whatever his conditions, potash —the producer of starch, sugar and strength of fiber— must not be allowed to run down in the soils which grow his crops.

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